BASF WYANDOTTE CORPORATION
Wyandotte, Michigan

POINT HENNEPIN

A Study of Development Potential

JOHNSON, JOHNSON & ROY, INC.
Planning/Landscape Architects
Ann Arbor, Michigan

March 1973

BASF Wyandotte Corporation

Wyandotte, Michigan 48192
313 282-3300

April 4, 1973

Mr. Dewitt Henry
Supervisor
Grosse Ile Township
8841 Macomb Street
Grosse Ile, Michigan 48138

Dear Sir:

Enclosed are 25 copies of the report, "Point Hennepin - A Study of Development Potential," prepared by Johnson, Johnson and Roy, planning/landscape - architects, Ann Arbor, Michigan.

The study is an independent appraisal of the characteristics of Point Hennepin that contribute to determination of its best end-use, and an evaluation of these characteristics in relation to the Grosse Ile Master Plan. We feel the consultants have done a fine job and submit their report for your review and future planning.

As part of the project, soil borings were taken to determine feasibility and actual design characteristics of the waste beds - the results indicate that Point Hennepin will support conventional construction using normal design criteria.

In their report, Johnson, Johnson and Roy develop in some detail costs, financial aspects and potential tax revenues based on development of the Point for residential use. We would like to emphasize that BASF Wyandotte is not contemplating such a program of investment. Rather, our interest has been to aid you in providing additional facts for use in Township planning. The calculation, therefore, serves only to indicate the contribution the site could make if fully developed to its highest use from the tax-revenue viewpoint and to reinforce Johnson, Johnson and Roy's confidence in the merits of Point Hennepin as a constructive factor in the development of Grosse Ile.

This report is for public distribution - additional copies are available, We welcome your comments.

Sincerely,

T. B. Piper

T. B. Piper
Manager of Wells

TBP/pc
[illegible]

POINT HENNEPIN

A Study of Development Potential - Purpose and Scope

A study by Johnson, Johnson & Roy directed toward identifying, describing and evaluating the development potential of Point Hennepin.

This study is sponsored by BASF Wyandotte Corporation as a contribution to Grosse Ile Township to further its efforts in the orderly development of the entire community.

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PREFACE

Point Hennepin, the northern tip of the island of Grosse Ile, Michigan, is essentially a fill area built up over a period of years by the deposition of disposal materials from chemical manufacturing operations on the nearby mainland. It has also served for the past 30 years as the base for salt production operations by the solution mining method. As the practical life for salt well operations approaches, Point Hennepin remains as a barren landscape, supporting little life or activity.

Nevertheless, as a land form the Point is physically part of the Island, and as such should be considered as an integral part of the Grosse Ile community. Recognizing this, BASF Wyandotte Corporation, owner of most of Point Hennepin, has determined that it was necessary to identify and evaluate the features of the site which contribute to a determination of its best uses. This study and report is the culmination of the corporation's concern.

It is intended that this effort be a contribution to Grosse Ile Township to aid in furthering its efforts in the orderly development of the Island as a total entity by integrating plans for Point Hennepin into the program for the entire Township. The study also is intended to aid BASF Wyandotte Corporation in establishing a long term program for its Point Hennepin holdings which has the concurrence and support of the Township's planning consultants.

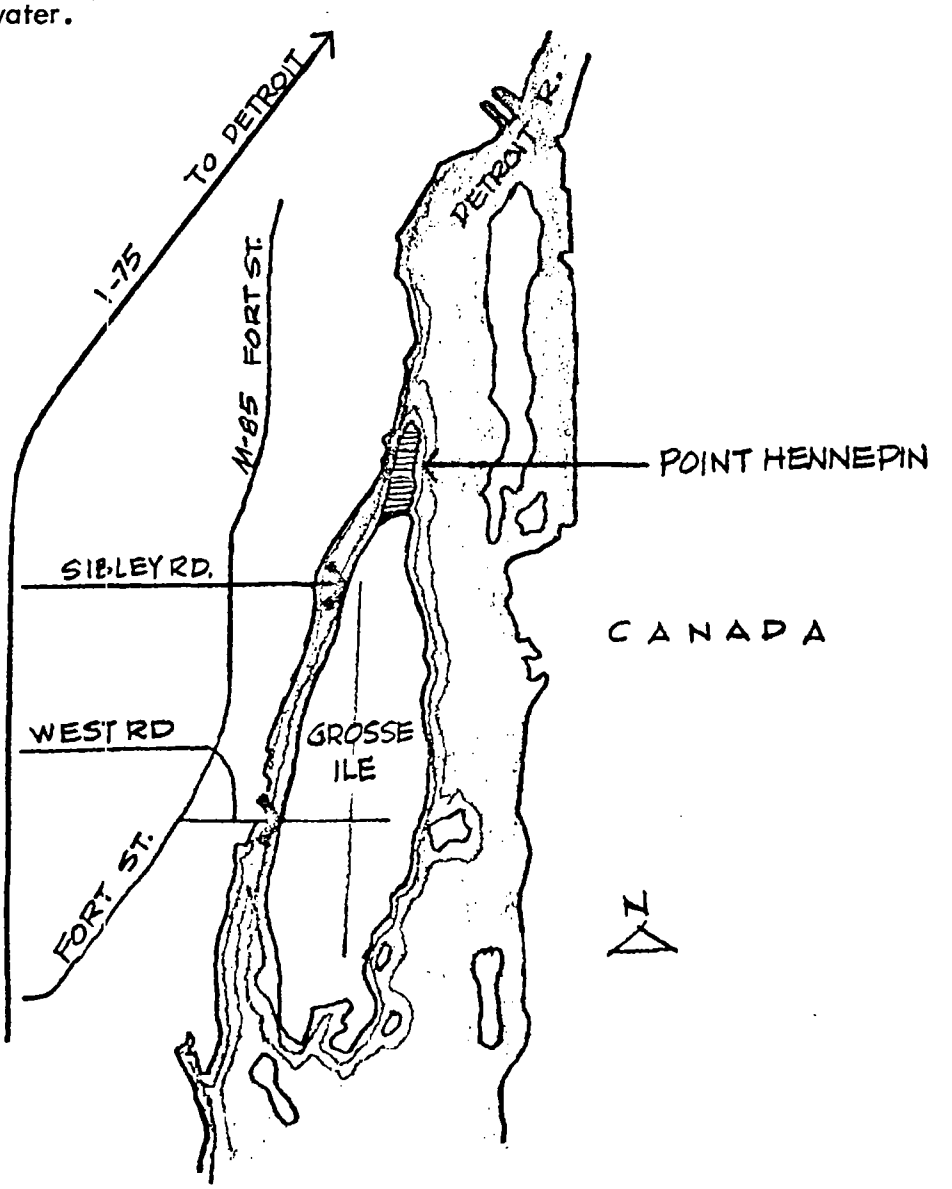
This report first identifies and discusses the LOCATION and geographic aspects of Point Hennepin, reviews its BACKGROUND, analyzes its SITE CHARACTERISTICS, and summarizes its POTENTIAL USES. A section on RESIDENTIAL ANALYSIS summarizes the ECONOMIC CONSIDERATIONS involved, and sets forth LAND USE RECOMMENDATIONS for consideration of the Township and the Owner.

This study was funded by BASF Wyandotte Corporation to provide the Township with an analysis of the characteristics of the Point and an appraisal of the impact of the two subsidence areas and their associated sinkholes on future uses of the Point.

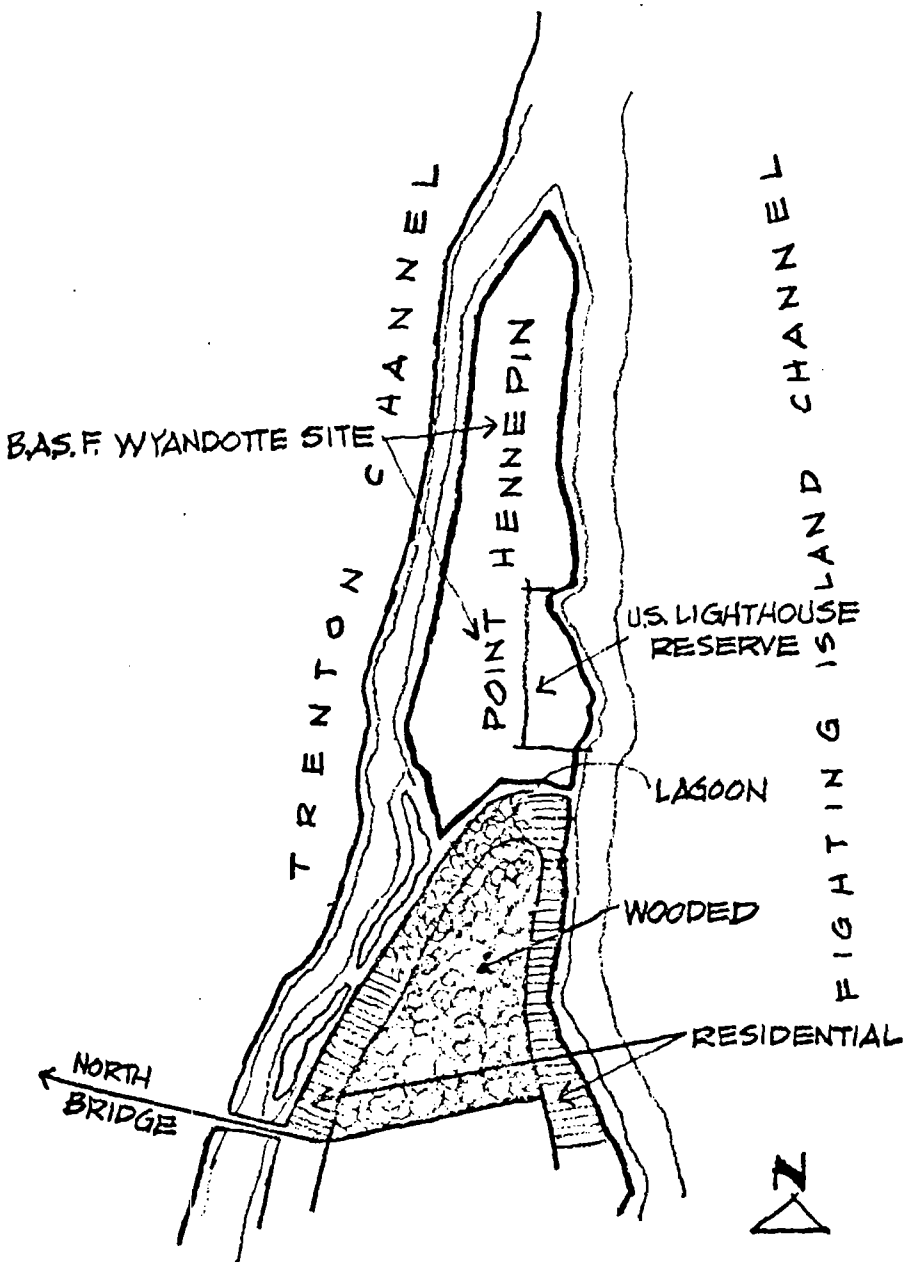
I. INTRODUCTION

Location

Grosse Ile is an island community located in the heart of the Downriver Industrial Area of Metropolitan Detroit. Separated by water, it is quite different from the intensely developed neighboring communities on the nearby mainland. It is basically a residential area unique because of its relative isolation from urbanized areas, its feeling of an open, natural environment, and its relationship to water.



LOCATION MAP



Point Hennepin is a narrow strip of land approximately one and one-third mile long and less than one-fourth mile wide at the north end of Grosse Ile. It is approximately 231 acres in size, 212.6 acres being owned by BASF Wyandotte Corporation and 18.4 acres owned by the federal government, controlled by the U.S. Coast Guard as a Lighthouse Reserve. The Coast Guard property has been declared surplus by that agency and offered for disposal. This study assumes assimilation of the parcel into Point Hennepin.

The Grosse Ile Township Comprehensive Plan prepared in 1969 designated

the entire Point Hennepin area as a passive recreation and natural area use zone. Within the total Point area a relatively small marina park was suggested for development on the Coast Guard property on the east shoreline facing the Fighting Island channel of the Detroit River.

The area on the mainland (separated by a lagoon), immediately south of the Point Hennepin site is zoned for single-family residential use. Development presently is confined to the east and west shore sections. The undeveloped interior remains as a natural woodland. The Comprehensive Plan set aside the interior woodland zone for single-family cluster housing with a system of uninterrupted open green areas linking adjacent future residential neighborhoods.

At the time the Comprehensive Plan was prepared, it was suggested that Point Hennepin remain open because of the possible constraints posed by the chemical land fill. However, it appears now that there are other uses which would be appropriate for this rather large, long lineal land reserve. This report considers these potential uses.

II. BACKGROUND

Point Hennepin owes its origin and existence to the chemical manufacturing operations on the mainland. Its recent history centers around brine wells which are employed to produce salt - one of the basic raw materials of the chemical operations. Because of the importance of the brine wells in the present situation on Point Hennepin, they will be discussed briefly here. Further information on salt operations can be obtained from the Michigan Department of Natural Resources, Geological Survey Division, and from a recent report prepared by BASF Wyandotte Corporation and the Solution Mining Research Institute concerning Point Hennepin.[1]

Salt production by the solution mining method began in the Detroit area during the last decade of the nineteenth century. Wells were drilled on the mainland on what is now BASF Wyandotte Corporation property which served manufacturing facilities nearby. Later, operations were transferred to Point Hennepin. BASF Wyandotte Corporation and its predecessor, the Wyandotte Chemical Corporation, have been producers of chlorine and soda ash in plants on the mainland which date back to 1890. These operations require salt as one of the principal raw materials. These salt needs have been produced from salt beds which underlie this area by a dissolving technique employing wells known as solution mining.

A brief description of this process is necessary to explain the formation of Point Hennepin. In solution mining, a typical group of wells is known as a gallery. Fresh water is pumped down a well designated as a feed well to dissolve the salt and the resulting brine is

[1] "Environmental Aspects of the Point Hennepin Sinkhole, S.M.R.I.," 1972

drawn to the surface by way of other wells in the group. The brine is pumped to the manufacturing facilities where it is used for chemical manufacture. Principal products are soda ash and chlorine. A residue, known as distiller blow-off (DBO) is a by-product in soda ash manufacture. Rather than dump this residue into the river, it was piped in hot liquid slurry to a swampy site on Grosse Ile where it was contained by dikes and allowed to decant in layers.

The disposal site originally was a submerged middle ground (a shallow marsh) extension of the north end of Grosse Ile known as Point Hennepin. The fill area was initially developed within a loop road contained by a dike stabilized on the edge of the water by riprap and filled to an elevation of approximately 8'. A second dike was later created within the original road from solids raked out of the disposal material to accommodate a fill area which eventually rose to be approximately 30' above the water. In the early 1950's the disposal operation on the Point was terminated. Concurrently, the site served for the location of salt wells operated in the underlying salt beds.

Because of serious "alkali dust blows", stabilization control measures were explored. In the 1950's at the suggestion of the Michigan State University Extension Service, experiments with stabilizing the surface with crown vetch and other grass varieties were undertaken. This met with little success, because of a lack of soil, and the alkali character of the fill material. Over the past 20 years however airborne soil particles of some nutrient value and seed from many sources have established a thin turf supporting small shrubby

plants on most of the fill area. This thin layer of vegetation serves as a valuable base for potential, more prolific vegetation growth and has arrested the dusting problem.

Two sinkholes have developed in recent years created by collapsing of the salt cavities underlying portions of this area. These have produced crater-like lakes with a water depth of 100' with 20' to 30' vertical walls to the water level. The sinkholes are surrounded by a broken area consisting of a series of cracks up to 3' wide which have developed in concentric rings. Similar sinkholes in other areas of the country, reported in the scientific literature, tend to show that the conditions that cause such a collapse become stable after the termination of salt production in the area, thus permitting backfill and restoration to practical use. To verify this, the edge of the affected material has been monitored and a line of 0 cracks has been established - in essence a line of stability. Blasting, hydraulic and dragging attempts have not been successful in breaking down the edges of the pits and, at the present time, they stand in their original condition awaiting decision as to their ultimate disposition.

III. SITE CHARACTERISTICS

Point Hennepin is a man-made island consisting of industrial waste with a thin veneer of airborne soil and largely volunteer vegetation. The two subsidence areas dominate the site, but otherwise, other than abandoned salt wells and their service roads are essentially the only evidences of development. Salt well operations in the subsidence areas have terminated - complete termination of operations on Point Hennepin is scheduled for the near future.

Access

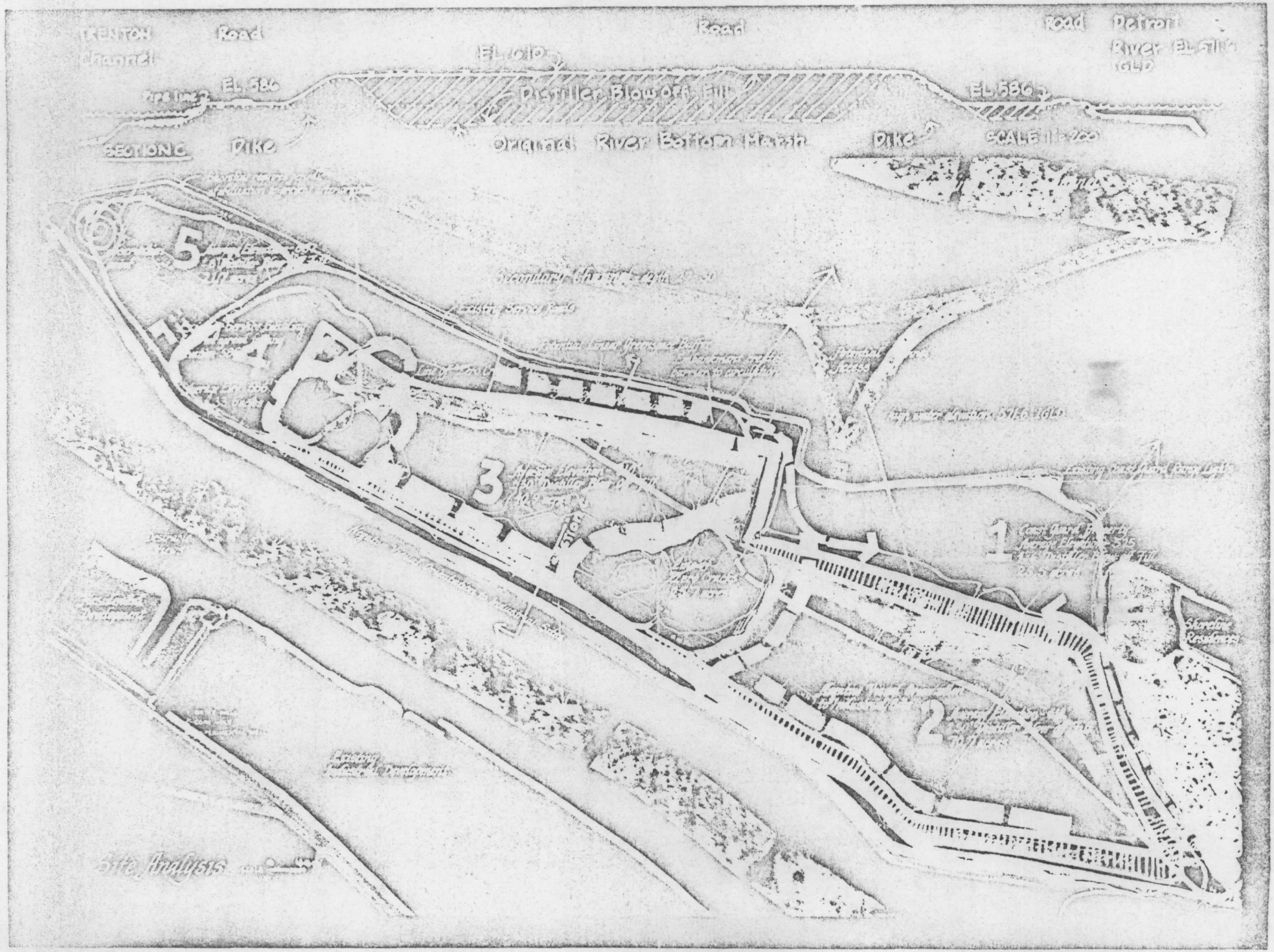
The site is separated by a lagoon from the Grosse Ile mainland to the south. The adjacent mainland is currently being developed as single-family residential. From the lagoon, Point Hennepin extends approximately 7,000' north with access thus limited to the south margin. Preservation of the lagoon will require the construction of a suitable bridge. The present access occurs at the southwest corner of the site providing linkage to a road that extends around the perimeter of the Point adjacent to the water's edge. Other roads have been developed on the stabilized fill on the top of the plateau 30' or more above the level of the water. The original use of these roads was to provide service access to brine well sites.

There is no vehicular access to the Coast Guard property although potential access appears to be feasible by extending Parke Lane over a new bridge into the site. The exact alignment of the access road would be dependent on the final layout of the proposed development for the site. This extension into the site could ultimately be connected to the perimeter road around the peninsula.

The Point has access to deep water on its east and west margins, notably the east side, where ocean-draft vessels can approach within 100-200' of much of the shore. The entire shore provides access to shallow draft vessels.

Orientation

The most effective and impressive visual orientation is from the high plateau and the water's edge on the east side of the Point facing the wide expanse of the Detroit River, the primary shipping channel and the horizon of Canada to the


Road
Road
Road
EL 680
EL 680
DIKE
DIKE
5
4
3
2
1

east. The west edge of the peninsula faces an industrial complex separated by about 900' of water, the Trenton Shipping Channel. Although the negative aspects of major industrial development have been continually improving, there is some concern of the impact of air and sound interferences on uses for the Point and particularly sites adjacent to this edge.

One of the most effective areas on the entire site is situated at the northernmost tip of the island where one can experience panoramic views surrounded on three sides by water. On a clear day one can see the urban skyline of Detroit's downtown. This view is available at both the northern lower portion of the site as well as from the middle and upper plateau areas. As previously pointed out, the south margin is adjacent to a single-family housing zone on the adjacent Grosse Ile mainland, although there is some pressure to consider for higher density residential use at about 4 to 5 units per acre in this section.

Primary Land Units

Topographically, Point Hennepin divides into five potential development zones. These are graphically shown on the Site Analysis Diagram which follows:

Zone 1 - Coast Guard and Adjacent Property

This zone is composed of the Coast Guard property (18.4 acres) and the low land area immediately south to the lagoon (± 7.1 acres). This zone offers the best opportunity to relate to the water in terms of development since it is only 4 to 6' above the level of the water. Also, since the waste material fill is minimal in depth, stabilization of areas for building would be less costly than other areas on the site. However, disposal of the spoils from excavation of a sheltered lagoon area may be a serious and costly problem. Also, the frequent water surge pressure caused from the swells of the shipping channel may have considerable effect on the feasibility and design of the marina.

Zones 2 and 3 - Upper Plateaus

The upper plateau is delineated by a steep slope retention dike. It includes the largest land areas, Zone 2 (± 70.7 acres) and Zone 3

(± 40.9 acres) comprising ± 111.6 acres. These zones are at an average elevation of 612', 30' above water level. The high plateau is divided by the south sinkhole area. A safety buffer of 50 to 200' beyond the 0 crack line discussed earlier has been established as a no development zone. A smaller subsidence area occurs at the north end of Zone 3 around which is also plotted a no development zone. At this time it is assumed that when this area is developed, these sinkholes will exhibit the stability observed at similar areas of salt well subsidence elsewhere. Also, consideration can be given to restoration of the original surface by backfill (as in other areas also).

The two large zones on top of the plateau are essentially open and flat having a very effective view to the east river channel and a negative visual orientation to the industrial sites on the west. Development should include a proposal for stabilizing the steep retention dikes as well as for the soils subject to wind erosion on the flat surface of the plateau.

Zone 4 - Intermediate Level

Zone 4 consisting of ± 33.9 acres occupies an intermediate zone of elevation between the high plateau and the lower areas of the site. This zone offers excellent visual orientation to the north and east and is accessible from the lower perimeter access roads.

Zone 5 - Lower Level

The final primary land area, Zone 5, is located at the northern tip of the peninsula where the land fill is only ± 8' above the water. The entire shoreline shows some indications of erosion. A conference with BASF Wyandotte Corporation personnel reveals that constant effort is required for its maintenance. Shoreline stabilization will be a major maintenance item of any development proposal for the entire site.

Surfacial Material

There is essentially no topsoil on the entire Point. Surfacial material consists primarily of wastes from chemical manufacturing plants nearby. The material

consists of carbonates and sulphates of calcium and magnesium formed as insoluble precipitates, plus sand, other silica and inerts resulting from slaking lime and minor solids which were transported to the site in a liquor of calcium and sodium chlorides. Particle size of the precipitates is approximately 40 micron. This material, having the moist and dense consistency of a wet clay, is relatively stable but does not support vegetation except where chlorides have been leached and a soil layer (airborne) has accumulated. The beds are horizontally layered in structure and are prone to shear vertically.

The surface can be stabilized with mats or gravel to support roads (as evidenced by the present roads) to accommodate fairly heavy service vehicles, as well as has been proven in the past, support heavy equipment.

Bearing Capacity

As part of this project soil borings were made by Michigan Drilling Company in the wastebed area and in the adjacent riverbed to evaluate the character of the fill material and soils and to assess the feasibility of construction on Point Hennepin. These were interpreted by Smith, Hinchman & Grylls Associates, Inc. The soil boring information and bearing analysis are contained in the Appendix to this report.

In summary of these investigations, it can be stated that structurally it would be feasible to build both low and high rise structures if the proper care were taken in foundation design.

Low rise buildings (not more than two stories) can be constructed using spread footings sized for a total design load of 2,000 psf. High rise structures (over two stories) could also be planned providing foundations be designed as piles or caissons which must extend down to glacial till hardpan.

Concrete slabs on grade should be suitably reinforced in both directions and have closely spaced control joints. Road construction should be designed of bituminous paving.

Other Aspects

Odors and Noise - The prevailing westerly winds pick up and carry pungent

odors, particulates and noise emitted from mainland industries across the Trenton Channel, a non-absorbtive level surface which amplifies their impact on the site. Abatement controls by the responsible industries in addition to carefully located and selected vegetation buffers would alleviate these factors.

Light at night from mainland industries could also have a negative impact on a number of uses especially residential. However, careful orientation of the buildings supported by an effective development of visual screens can ameliorate this problem as it has in many situations on Grosse Ile.

Deep Water Access - The site is adjacent to two primary shipping channels having the capability of accommodating ocean going vessels including freighters that could service in and out shipments.

Utility Access - Primary power and waste disposal is available to the site from the mainland assuming tunnel construction is feasible under the Trenton Channel. There is also an abundance of water available for cooling purposes.

IV. LAND USE POTENTIAL

Based on the afore information and the primary development goals of the Grosse Ile Comprehensive Plan to achieve

- o A quality residential environment
- o Preservation of its natural resources
- o Expanding and protecting its greenery
- o An interrelated system of open space for community use
- o Expansion of conveniently located uses servicing the local residential community
- o Uses compatible with character and size of the entire community,

we propose the following uses for Point Hennepin in order of their priority:

1. Residential

   A low density development with living units distributed through a matrix of open space, part of which could be used for active recreation. The prime orientation would be toward the eastern shoreline with the west shore set aside and developed as a visual and physical buffer from major industry on the mainland. With the provision that further, more in-depth studies justify its use, a Marina on the east shore would expand a high demand recreational activity.

   Realizing that the basic land development costs may be out of proportion to the economic gain, we still strongly recommend a relatively low density residential development for Point Hennepin. This use would strengthen the local market base, continue the visual character and open space plan of Grosse Ile and would not overburden the infrastructure, especially the community road system.

2. Institutional

   Any institutional use such as a small private college, rehabilitation facility or research institute that would impart minimum impact on the site and community would be acceptable. The assumption of

the site plan should include ample open space, landscape buffers, continuation of community pedestrian pathways to the tip of Point Hennepin and possibly provision for shared water frontage.

3. Light Industry

"Environmentally clean" industrial use, possibly those related to research, may be acceptable. The primary concern would be the size in terms of generating excessive traffic and overburden on the local utility systems.

A well designed industrial park, that would continue the open space and landscape character with primary access to the mainland from the north bridge avoiding major conflicts with the local community traffic system, may be desirable. There is some question however about the marketability of light industrial use on Point Hennepin concurrent with the Airport Industrial Park.

4. Local Community Park

The Grosse Ile Comprehensive Plan designated Point Hennepin for use as a major local park blending into cluster housing development contiguous to the south property line. The park featured a large public marina as its central focus of activity.

Although the use of Point Hennepin as parkland is still the most ideal, excessive costs for basic land reclamation and extensive planting for buffering the west shoreline for aesthetic purposes may prove to be entirely infeasible.

Other uses such as a golf course, regional park, airport and various types of primary commercial facilities have been evaluated and eliminated from further consideration because of infeasibility or incompatibility with the Grosse Ile Comprehensive Plan.

V. RESIDENTIAL DEVELOPMENT ANALYSIS

Residential use shows the high use potential relative to the long range development plan of Grosse Ile and a basic economic return from the land. Therefore, we have prepared layouts and developed cost estimates for several plans of Point Hennepin.

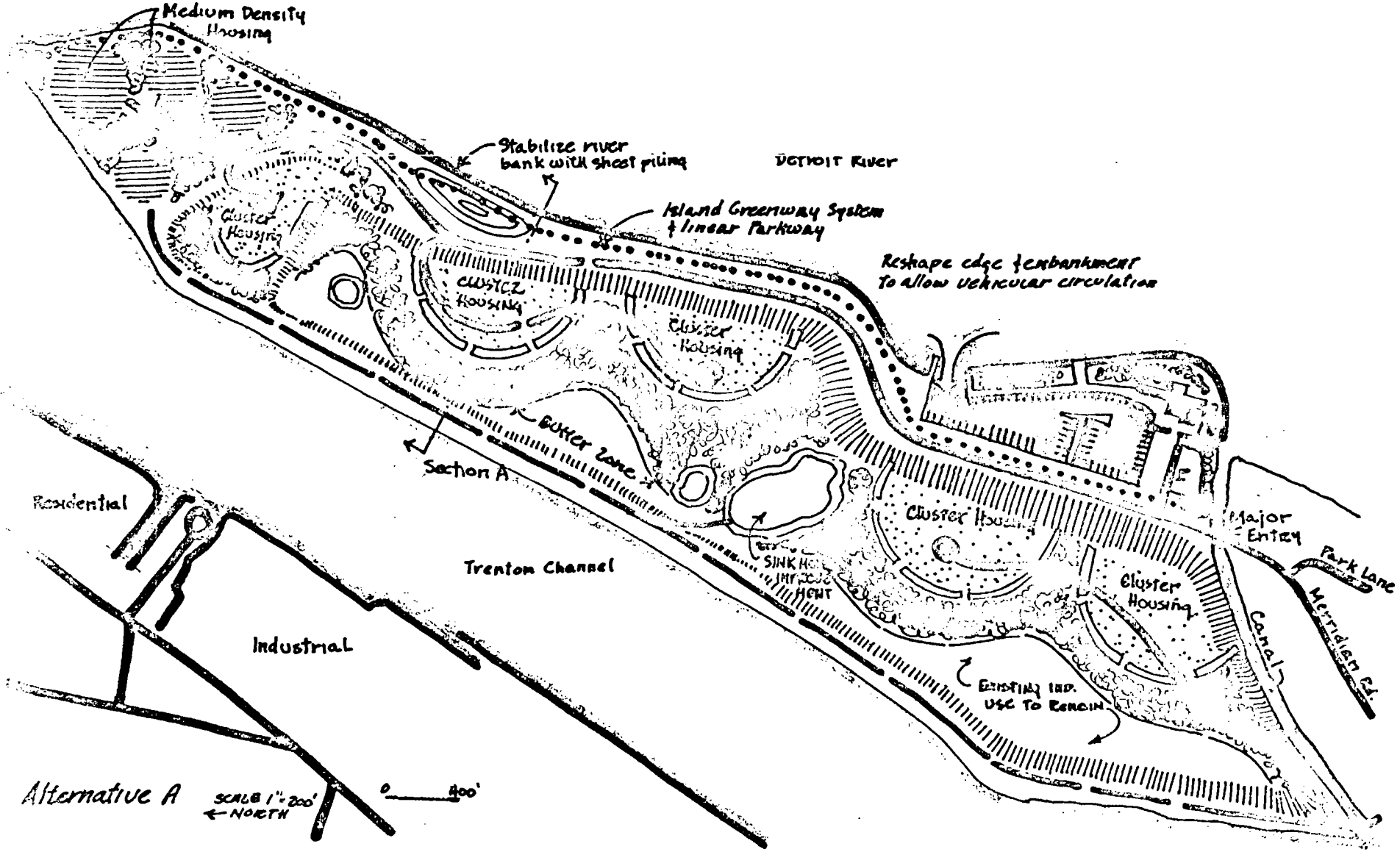
Three development schemes have been developed for the Point Hennepin site as residential use examples. The particular characteristics of each of these have been selected to analyze and illustrate a maximum to minimum intensity of development.

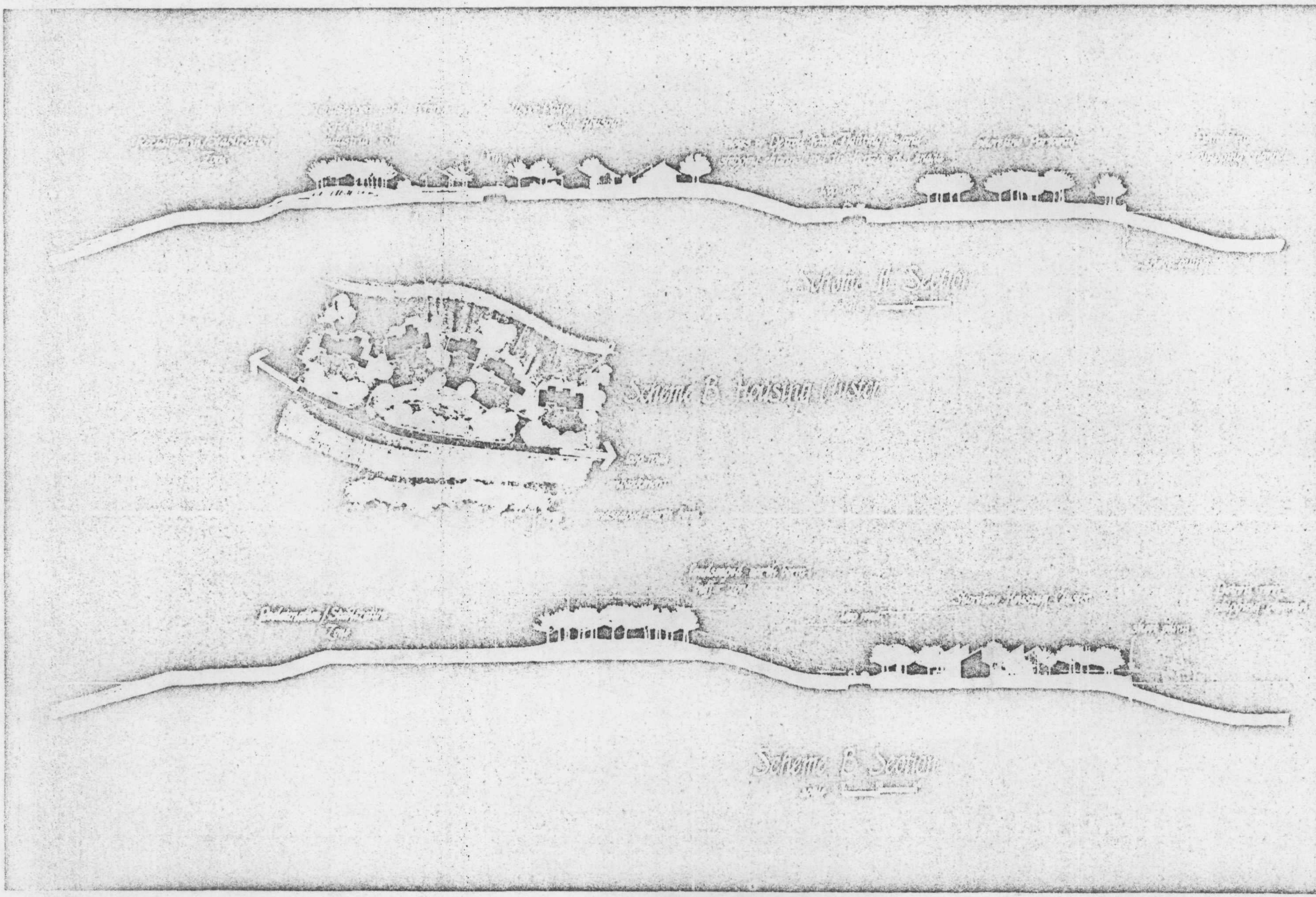
Scheme A

Schematic Development Plan A is essentially programmed for a low density housing project linked and related to recreational use edging the east shoreline. The primary recreational use area is focused upon a semi-public marina. Residential uses break down into two primary housing zones and types.

The first residential zone would consist of a low density cluster housing area located in four clusters along the edge of the plateau (Zones 2 and 3) overlooking the river to the east, and one cluster at the intermediate level oriented northeast. Each cluster would be surrounded by a 6 to 10 foot high landscaped earth berm which would provide insulation from the industrial edge to the west. The five clusters would be programmed to accommodate 140 living units at a density of 3 $\pm$ units per acre. The clusters would consist of attached townhouse units which would be arranged lineally facing each toward the east. The area around the sinkholes and a portion of the plateau along the entire western edge would be set aside as a no development zone, although there may be a minimal commitment to site stabilization and fill for some landscaping.

Access to the clusters on the plateau would be gained from a primary roadway edging the eastern shoreline. The roadway would be developed as a parkway meandering through a lineal park that also could serve for


Medium Density Housing
Stabilize river bank with sheet piling
Detroit River
Island Greenway System & linear Parkway
Reshape edge of embankment to allow vehicular circulation
Cluster Housing
Cluster Housing
Cluster Housing
Buffer Zone
Section A
Residential
Trenton Channel
Industrial
Cluster Housing
Major Entry
Park Lane
Meridian Rd.
Canal
Cluster Housing
Existing Ind. use to remain
Alternative A
SCALE 1" = 200'
NORTH
0
400'


Scheme A Section
Scheme B Housing Cluster
Scheme B Section

recreation uses. Almost the entire shoreline edge paralleling the parkway should be stabilized with sheet piling in combination with riprap.

A second housing zone would be programmed for the tip of the Point occupying 10 acres of land at a net density of 10 units per acre. To achieve this density, garden apartments or close knit townhouse clusters must be used as a housing type. This housing zone would be located at the terminus of the parkway discussed above, therefore, some provision would have to be made for an adequate turn-around or a connection made to the west perimeter road which would provide a loop system around the entire site. If the loop system were used, the west portion would have to be attractively landscaped, which of course would substantially increase the development investment requirement.

A semi-public marina is suggested for the Zone 1 site. A marina clubhouse facility would be suggested at the promontory of land on the southeastern shore. The entire shoreline of the marina would be designed as a lineal park where boaters could enjoy picnics and the impressive views across the river to Canada. A boardwalk promenade would line the boat storage area parallel to a vehicular access road. A parking area for 120 cars would be located contiguous to the entrance road just west of the clubhouse area and a lineal parking area would parallel the boat storage area on the west edge of the marina. The primary development problem in the marina area would center around the disposal of excavated material from the lagoon itself. Once the DBO is removed, the river bottom soils could be used to stabilize the park areas around the marina. Additional organic fill would be required to support plant material.

In summary, the plan offers a low key 240 unit residential community distributed through a lineal park-like setting having a marina as its primary recreational activity. This type of development should be quite marketable, especially in the Grosse Ile area, since it is oriented to a low density quality residential environment and the water recreation opportunity which literally surround the community. However, the only

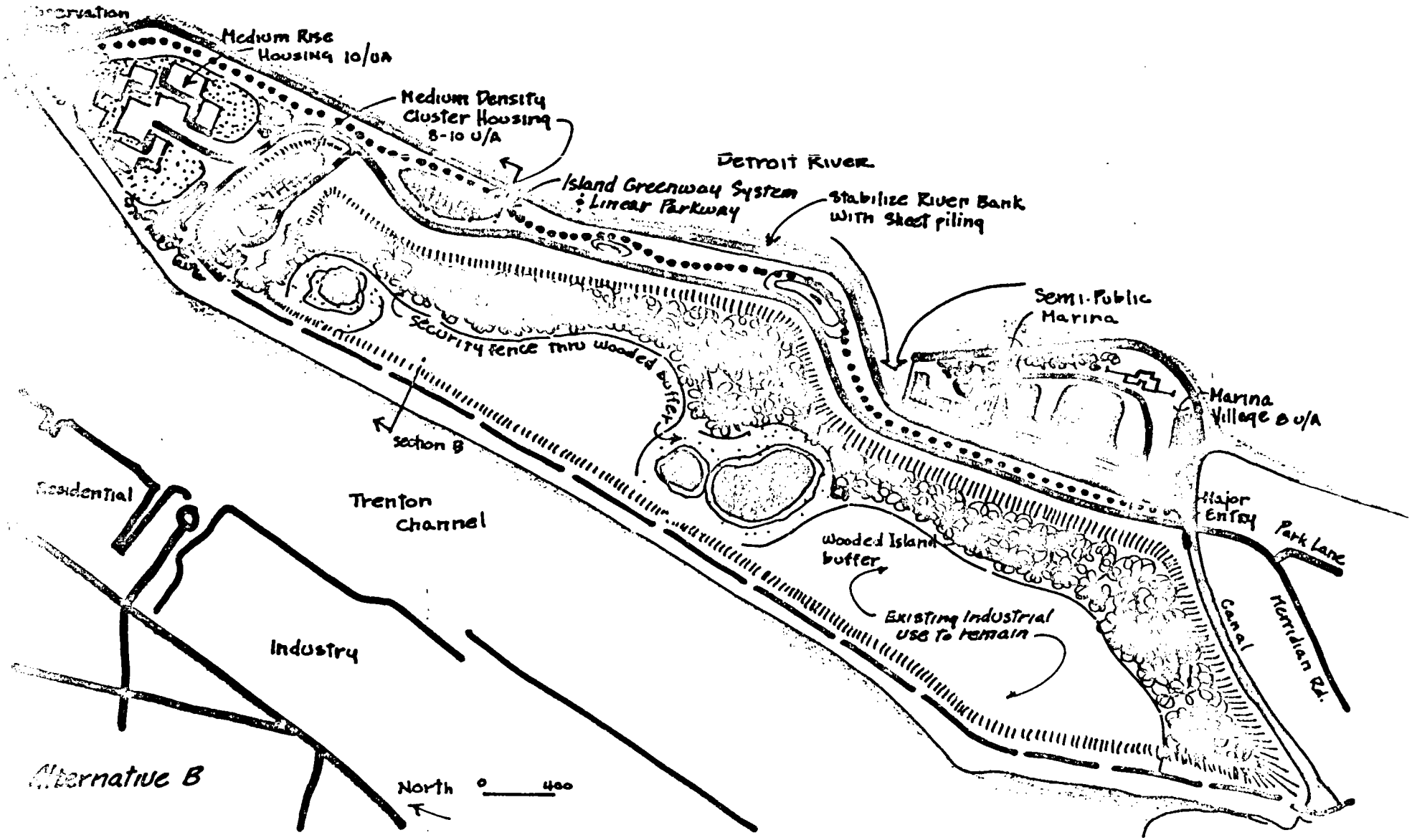
major drawback is the development cost which demands inordinate costs of reclamation in proportion to the potential income from the housing and marina uses. These costs will be mentioned in more detail under economic consideration and cost of development.

Scheme B

Schematic Development Plan B, while including similar uses for housing and recreation as Scheme A, suggests a considerably different layout and a slightly higher density.

In terms of housing, the plan is based on medium rise housing on 16 acres of land on Zone 5 at the tip of the peninsula at 10 units per acre or 160 units. Medium density housing at a density of 8 units per acre is suggested for three areas. The first would be located at the north end of the site on Zone 4, the intermediate level plateau. This site can accommodate approximately 68 townhouse units, lineal in layout and overlooking the river north and east. A second cluster would be located on 2.5 acres of land on the lower land fill area parallel to the river on the east edge. The third medium density housing zone would be proposed as a marina village which would include highly marketable marina oriented townhouses having dual orientation both to the river and inward to the lagoon. Common facilities would include a clubhouse and boat storage for the residents. Again as in Scheme A, the east waterfront edge would remain open as a common greenway.

Primary access to the housing clusters would be from a linear parkway similar to the one suggested in Scheme A. Over half of the parkway system would be edged by a lineal greenway park allowing access to the river and a separate walkway along the entire eastern shore to an observation point at the northern tip of the site. This walkway system could be linked into a bicycle/pedestrian route traversing the entire length of Grosse Ile. In clusters along the edge could be picnic tables, simple barbecue stands and benches suggesting more active use. The vehicular parkway and the park system should be carefully planted to optimize its


Medium Rise Housing 10/UA
Medium Density Cluster Housing 8-10 U/A
Detroit River
Island Greenway System : Linear Parkway
Stabilize River Bank with Sheet piling
Semi-Public Marina
Security fence thru wooded buffer
Section B
Marina Village 8 U/A
Residential
Trenton Channel
Major Entry
Park Lane
Wooded Island buffer
Existing Industrial use to remain
Canal
Merridian Rd.
Industry
Alternative B
North
0
400

aesthetic value.

One of the primary differences between Scheme A and Scheme B is the use of the high plateau. Because of the extremely difficult problems of stabilization on this area, in Scheme B the area would remain open and developed over a period of time as a park. The first phase of development would entail the construction of long lineal rolling mounds with stabilized loamy clay soil fill. The mounds and the area between would be planted with a mixture of vegetative types. The prominent type would be a durable long lived shade tree, the root system of which would establish a foundation for supporting species. The planting plan for this concept would have to be thoroughly worked out in terms of site adaptability, land fill and sequence of implementation. The second major phase of development could then be focused on the creation of a park development that would include active recreation uses. The goal in time would be to develop a sizable multi-use park that could be used both by the adjacent residents and the residents of Grosse Ile.

This scheme would require a major shoreline stabilization plan. This could be accomplished with riprap or steel sheet piling that would absorb the variable ice action from the Detroit River and the shipping channel. It has been shown that riprap, while aesthetically more pleasing, requires continual maintenance. Sheet piling would eliminate this recurring cost, but care should be taken in design to soften its harshness and prove that it is safe.

In summary, Scheme B, accommodating 328 housing units, 88 more than Scheme A, concentrates development in key areas that are more developable in terms of soil capability. The more compact development units require less investment per unit in terms of site costs while at the same time achieving a 30% increase in density. The scheme also sets aside the difficult development area on top of the plateau for a less intense use; a plan that can be achieved over a period of years without affecting more intensively developed zones on the lower lands closer to the water. This plan avoids committing development around the subsi-

dence area allowing additional time for stabilization. Although alternative Scheme B appears to be more logical in terms of economic feasibility and phasing of development related to site problems, there is still a great deal of concern regarding the basic cost of site reclamation and preparation in the developable zones.

Scheme C

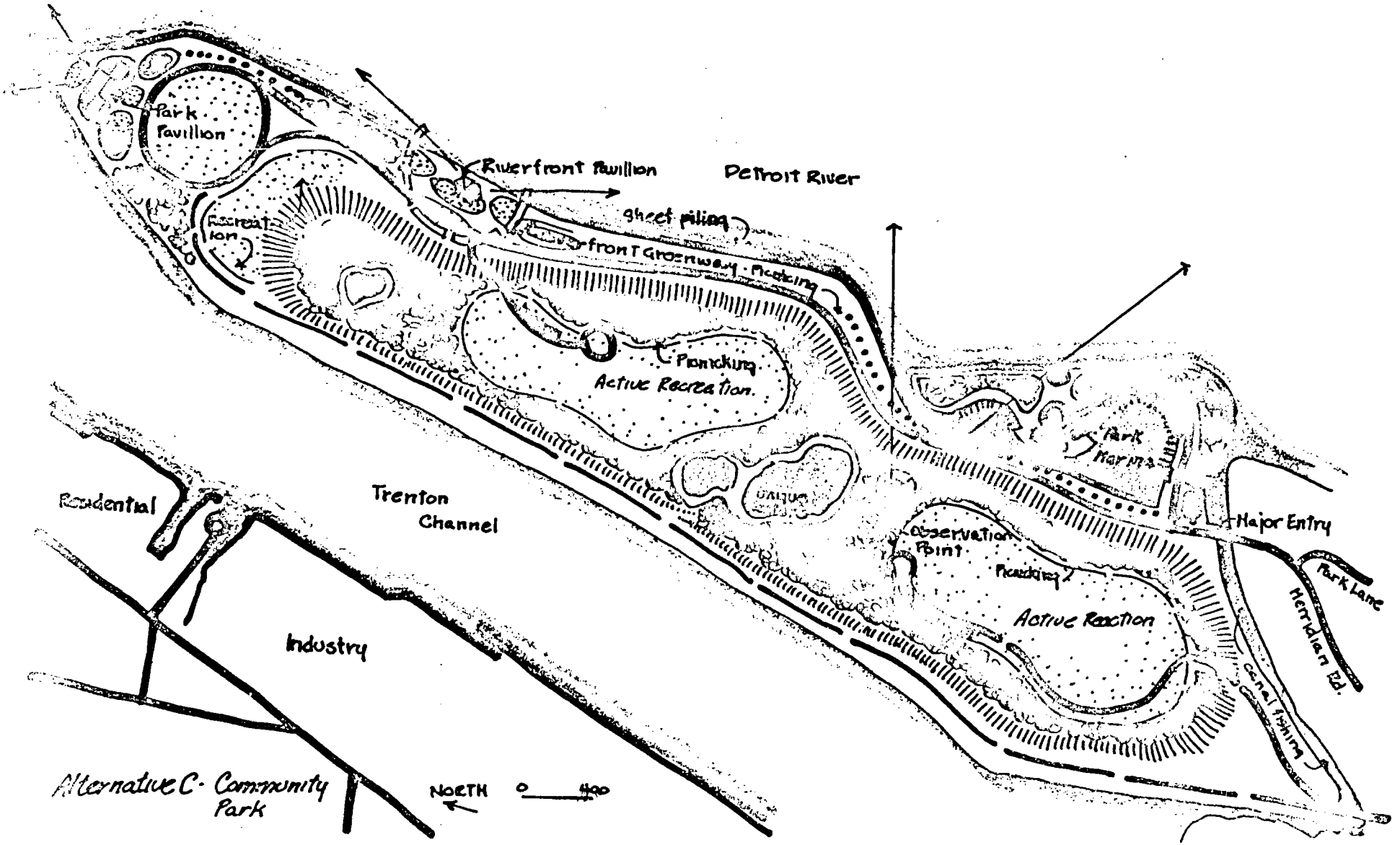
Recognizing the Grosse Ile Comprehensive Plan, Scheme C has been developed as a community park featuring three prime development activities:

1. a park marina in Zone 1
2. a riverfront pavilion along the eastern shoreline
3. a large park pavilion at the prime observation area on Zone 5

In this scheme each of these primary use areas would be connected to a tree lined parkway having as its terminus a large cul-de-sac at the northern tip of the peninsula. Parallel to the parkway would be lineal walk and bicycle pathways linking the various activities with similar systems suggested in the Comprehensive Plan.

The park marina would include accommodation for up to 100 boats which could be divided into transient and more permanent leased boat slips. The park marina would also serve to provide picnic and overlook areas for other than users of the marina.

The large plateau would be developed as a natural informal park featuring large open areas for active recreation field sports adjacent to picnic areas distributed throughout the entire area. The sinkholes would be surrounded by planting and featured from overlook areas. Although visual access would be provided, physical access would be prohibited with planted walls and fences surrounding them. The steep walls surrounding the sinkholes should be stabilized if feasible or necessary. As previously mentioned under treatment solutions for the sinkholes, the most feasible and functional solution is filling the deep cavi-


Park Pavillion
Riverfront Pavillion
Detroit River
sheet piling
front Greenway Planting
Recreation
Picnicking
Active Recreation.
Park
Marina
Residential
Trenton
Channel
Major Entry
Observation Point
Picnicking
Active Reaction
Park Lane
Herridan Rd.
Canal Parking
Industry
Alternative C- Community Park
NORTH
0
400

ties with engineered backfill. A source for fill could possibly be dredging material from several Downriver dredging operations at minimal cost per yard, if anything.

One of the prime development tasks would be the stabilization of the steep walled dikes, the problem being especially difficult on the high bank surrounding the high plateau. As in the other schemes, a major development item would be the stabilization of the eastern shoreline and the edges around the marina.

Each of the three schemes should include consideration for cleaning out the existing channel between the Detroit River and the Trenton Channel over which would be the construction of a bridge linking the development areas with the main part of the island.

VI. ECONOMIC ANALYSIS

Tax Revenue Potential

The BASF Wyandotte Corporation is responsible for $134,000.00 in taxes each year for their Point Hennepin holdings. This, of course, represents a major contribution to the tax base of Grosse Ile Township. In order for Grosse Ile to receive the same tax income on the basis of their present $60.00 per $1,000.00 assessed valuation millage rate, a development scheme would have to include 75 housing units having the average market value of $60,000.00 per unit assuming a 50% valuation of tax base. Economically this would be entirely unfeasible because of the extremely heavy basic reclamation investment required in each scheme even before development begins.

The potential tax income from Scheme A based on Grosse Ile Township's present millage could generate $492,000.00. The derivation of the income is from the assumption that there would be 240 housing units having the market value of $60,000.00 and an assessed valuation of $1,000,000.00 for the public marina.

Scheme B would generate $624,000.00 per year with the assumption that 240 of the units were assessed on the basis of a market value of $60,000.00 and 80 of the units comprising marina village would be assessed at a market value of $80,000.00 because of the related amenities. The assumed tax rate is 60 mills.

Whether or not the remaining open land in each of the schemes would be assessed on the basis of land value in terms of developed and undeveloped open space would relate to whether the land could be taken over and maintained as public open space for the residents of Grosse Ile. Depending upon the valuation and disposition of the open space system, the land would have a tax income value from 0 to approximately $100,000.00. Therefore, the maximum potential tax income would be generated from Scheme B with all the open space privately owned by the residents, a total of $724,000.00.

Although a great value to the community, Scheme C, if developed, would

offer very little opportunity for generating tax revenues for Grosse Ile Township. The only option in alternative C would be the disposition of the park marina. It could be privately owned and operated within the context of the plan or publicly owned and leased for private operation, each of which could bring in tax revenues to the Township, but no more than $50,000.00 to $60,000.00 per year.

Basic Site Development Cost

The following is a cost analysis for Scheme A and B. The basic site cost includes only those items for the developed areas of the schemes to construct the major infrastructure, the landscaping of the open common areas and necessary fill for stabilization. Detailed site development within the housing areas is excluded; work covering utility hook-ups, secondary walkways, parking areas, planting around the living units, outdoor lighting and storm drainage. The cost for these items is more appropriately associated with detailed building development.

Scheme A

Open Space

Topsoil fill 6" deep	72,072 CY	$ 7.00	$ 505,000.00
Grass	84 Acres	$2,000.00	$ 168,000.00
Wooded Island fill 3' deep	253,333 CY	$ 7.00	$1,775,000.00
Planting	2,280 Trees	$ 200.00	$ 456,000.00
Roadway	10,000 LF	$ 20.00	$ 200,000.00
Sewer and Water	10,000 LF	$ 40.00	$ 400,000.00
Sheet Piling	7,000 LF	$ 20.00	$ 140,000.00
Walkways	6,800 LF	$ 5.00	$ 34,000.00
			$3,678,000.00

Scheme B

Open Space

Topsoil fill 6" deep	58,172 CY	$ 7.00	$ 407,000.00
Grass	68 Acres	$2,000.00	$ 136,000.00
Wooded Island fill 3' deep	133,333 CY	$ 7.00	$ 935,000.00
Planting	1,200 Trees	$ 200.00	$ 240,000.00

Roadway	86,000 LF	$ 20.00	$ 172,000.00
Sewer and Water	8,600 LF	$ 40.00	$ 344,000.00
Sheet Piling	11,200 LF	$ 20.00	$ 224,000.00
Walkways	7,200 LF	$ 5.00	$ 36,000.00
			$2,494,000.00

These costs exclude the marina primarily because of the lack of detailed soil information which would have an appreciable effect upon the size, form and engineering aspects of this portion of the project area. However, we use $5,000.00 per boat for rough cost purposes under similar circumstances.

Basic Land Reclamation Scheme

The most critical problem affecting development and economic feasibility of Point Hennepin is the basic responsibility of reclaiming the land. This should be accomplished particularly if development does not become a reality for an extended period of time in order to take advantage of current costs and to allow the site to stabilize. Basic costs to implement reclamation are set forth below. These costs would also be fundamental to the accomplishment of Scheme C.

Assuming the reclamation of approximately 200 acres of land, excluding the Coast Guard property, furnishing and distributing topsoil to a depth of 6" would require 170,000 cubic yards which at $7.00 per cubic yard would total $1,190,000.00. The $7.00 unit cost would include the delivery, spreading and compaction of the topsoil to a depth of 6". This can be accomplished either by using balloon tire vehicles or spreading topsoil in winter when surface is frozen. Seeding the entire 200 acres would cost approximately $2,000.00 per acre thus adding a total of $400,000.00. Thus, the basic cost of stabilization would be $1,590,000.00 or $7,950.00 per acre.

In addition to basic stabilization and surface drainage, the area would require additional development to achieve a natural park-like character. Additional fill of 125,000 cubic yards would have to be brought in to accommodate plant materials requiring greater depth of nutrient topsoils, a total cost of $900,000.00. Plant materials would cost $200,000.00 to achieve a minimum park-like image thus adding another $1,100,000.00 to the basic cost of stabilization. The total cost for basic land reclamation excluding the Coast Guard

property would be $2,690,000.00 or $13,450.00 per acre.

The present land market values in the area cannot possibly justify these excessive reclamation costs. Although it is difficult to justify costs of this magnitude at today's market prices, the future market will undoubtedly change as the Downriver area continues to grow and land becomes a scarce commodity. This is especially so on the island of Grosse Ile, the most attractive residential environments of the Downriver area.

VII. RECOMMENDATIONS

Each of the three development schemes described herein are consistent with the Grosse Ile Comprehensive Plan. Even though Point Hennepin was designated as a recreational park, a low density residential development with generous open areas that can be utilized for recreation satisfactorily carries out the intent of the island's Master Plan.

Other uses such as commercial, light industry or office have been considered, but appear to be inconsistent with the primary land use patterns of the Comprehensive Plan. The central zone of Grosse Ile is planned as a multi-use Town Center featuring an intermix of office and commercial facilities. Light industry and research oriented uses are programmed to be a part of an Industrial Park contiguous to the airport. The commitment of other areas scattered throughout the island to these particular uses would only dilute the image and function of the particular centers planned.

Additional functions which have been considered such as an airport or shopping center appear to be inconsistent with good concepts of land use or are completely impractical. Although it is difficult to conceive of Point Hennepin as a feasible site for an institution, it is possible that if any reasonable offers that recognized the inherent character of Grosse Ile and the basic goals of the Comprehensive Plan were made, the use may be compatible.

Scheme B set forth herein offers the most reasonable economic return on investment, assuming the cost of footings for the medium rise housing can be justified. The plan also has the additional advantage of reserving the high plateau for future residential development as the land is stabilized. Thus, the cost of land reclamation can be spread out over a period of years.

VIII. SUBSIDENCE AREAS

Impact of Sinkholes

Public concern over the sinkholes, particularly from the residents of Grosse Ile, was apparently due to the fear that the entire area was undermined and adjacent residential areas would be eventually inundated. A recent study sponsored by the Solution Mining Research Institute and BASF Wyandotte Corporation has confirmed that the sinkholes are centered on and confined to the two main brine well galleries. Also, the report pointed out that after one year, substantiated by close observation, that surface equilibrium has been reestablished. To further allay citizen concern, the study cites a similar sinkhole formation related to salt production occurring at a brine field in nearby Windsor, Ontario, in 1954. The depression has since been back filled, a railroad siding traversing the area rebuilt and operations resumed. Field observations as recent as 1971, seventeen years later, indicate little if any further subsidence.[2]

Recommended Treatment

The subsidence areas and sinkholes can be developed and be utilized in a number of ways. Each would relate to the overall goals of the land use chosen to develop. However, there are two basic treatments:

1. Leave the depression open and develop as a

    a) Lake - either as an aesthetic feature viewed from a landscaped park-like buffer zone or as a small protected, inland recreation lagoon. If used for recreation, necessary access to the shoreline will have to be constructed by grading the steep, sheer 30' high walls down to a maximum of 20 to 25%. Even if the lake were utilized as an aesthetic feature, the side slopes would have to be cut back to allow adequate angles of view from the top of the plateau.

[2]Landes, Kenneth K., and Thomas B. Piper, "Effect Upon Environment of Brine Cavity Subsidence at Grosse Ile, Michigan, 1971", Solution Mining Research Institute, 1972.

b) Marina - a channel cut through the 30' of tailings overburden to either the Trenton Channel or the Detroit River, would allow boating access to protected lagoons formed by the steep walls of the sinkholes. The feasibility of a project of this nature is in doubt primarily because of the problems and cost involved in stabilizing and retaining the steep slopes. There is also the question of chloride content of the sinkhole water in terms of effect of corrosion on water craft, docks, etc. and pollution potential caused by opening up a channel to the Detroit River.

2. Back fill and restore the surface

This solution would essentially eliminate the problem of the sinkholes. Similar subsidence depressions have been filled and restored to productive land use. The land area recovered could be utilized effectively in each one of the recommended residential schemes. Availability and cost of land fill should be measured in terms of the value gained through land use and environmental quality.

Without further detailed engineering and cost studies, it appears that the most appropriate solution would be back filling, using materials and methods that would establish a stabilized land surface. This would alleviate the public concern for further subsidence and eliminate the sinkholes as hazards. Furthermore, the recovered land can be utilized more productively as well as adding to the use efficiency of adjacent land areas.

A P P E N D I X

A. Soil Analysis
JJR - Smith, Hynchman & Grylls, Detroit, Mich.

B. Soils Exploration Report
Michigan Drilling Company, Detroit, Mich.

C. Corehole No. 2 - Grosse Ile - Composite Log
BASF Wyandotte Open File Report
(partial log of upper 100')

APPENDIX A

Soil Analysis
JJR - SHG

APPENDIX A

Soil Analysis

General

The chemical nature of the distiller blow-off deposit has been described as a tailings deposit consisting of compounds of carbonates and sulfates of calcium and magnesium plus silica, layers of lime and solids transported and decanted in a liquor of calcium and sodium chloride. The intersticial spaces contain residual chloride liquor except where leached in higher or well drained areas.

Underlying this chemical deposit are the original soil formations of the Detroit River bed, consisting of silty blue clay, extending 60' below river level. This in turn rests on glacial till hardpan; beneath this is the eroded limestone which constitutes bedrock in this area.

The intent of this soils analysis is to search out the impact of soil quality on the recommended development plans, and to determine basic construction guidelines related to existing soils.

Subsurface Investigation

Two sets of soil borings were made by Michigan Drilling Company, one set in 1971 and the other in 1972. These borings were made to investigate the character of the waste beds, the bottom of the Detroit River bed deposits and glacial deposits. The first borings, by Michigan Drilling Company Job No. 71-970, Holes D-1 and S-1 (see Appendix B), taken in the riverbed adjacent to the Island; they showed typical soft silty blue clay extending down to hardpan about 70' below river bottom. The soil samples were tested in the laboratory. The tests indicated

moisture content about 18%, unconfined compression strength about 1,800 psf to 800 psf for the soft clays with SPT (Standard Penetration Test) of 4 blows to 12" penetration.

A test hole (designated as a corehole - #2) was drilled through the bedrock formations to a depth of 1,300 feet in September 1960. This indicated bedrock formations to start 92' below elevation 610.5, and confirmed the presence of various materials such as limestone, sandstone, salt and water (see log of Corehole #2).

The second set of borings by Michigan Drilling Company, Job No. 72-616, Holes B-1 and B-2, was taken in the waste bed area in July 1972. Boring B-1 was drilled on the lower north terrace and B-2 was located on the upper terrace. See location drawings.

The physical characteristics of the chemical deposits and the underlying soil of the second set of borings were defined by triaxial shear tests, Atterberg limits and Shrinkage limits. Values obtained were tabulated for comparison.

Sample Depth	Test Types	Test Values: Chemical Deposits	Test Values: Soft Clay Formation
	C'	1440/2 = 720 psf	
5 ft.	ø	19°	
	SPT	2	
	Shrinkage Limit	75.2%	
	Liquid Limit	107.25%	
	Plastic Limit	81.0%	
	Plasticity Index	26.25	
20 ft.	C'		830/2-415 psf
	ø		15.5°
	SPT		15
	Shrinkage Limit		15.31%
	Liquid Limit		29.20%
	Plastic Limit		15.35%
	Plasticity Index		13.85
24 ft.	C'	1185/2 = 593 psf	
	ø	27.5°	
	SPT	3	
	Shrinkage Limit	86.25%	
	Liquid Limit	113.25%	
	Plastic Limit	98%	
	Plasticity Index	15.25	

Where C' = cohesion
ø = angle of internal friction
SPT = standard penetration test
Water Level = 9 ft. to 23 ft. below grade

Subsurface Foundation Analysis

Shallow foundations for structures would generally bear in the fill layer 5' below existing grade. Deep foundations would extend through the fill and clay and reach hardpan. In reviewing test results, shallow foundations would be subject to plastic to semi-plastic behavior of the subgrade. The chemical deposits have higher shrinkage limits than the underlying soft clay formation. Therefore, the subgrade would be subject to excessive settlements under loads that may be above 1,000 psf. Also, the mass stability of excavations down to 24' in depth would require extensive and complex bracing systems that are not generally encountered in normal construction.

Using local data in the above equation indicates that footings resting 5' below grade on the chemical deposit with $\phi = 19°$, the ultimate bearing capacity would be 13,300 psf for a 10' wide footing. However, high shrinkage limits of this deposit indicate that the material is more plastic than semi-plastic, and the angle of internal friction may not be a usable parameter for determining allowable bearing capacities for spread footings.

Shallow foundations should be sized so as to exert no more than 2,000 psf pressure on the subgrade. Structures with heavy column loads should not rest on shallow foundations, but should have foundations extending down to hardpan by the use of piles or caissons.

Uniformly spaced columns with loads not to exceed 20% differential may be placed on shallow mat foundations or strap footings. The mat should be stiff so as to equalize pressures as its extremities with those at its center of gravity.

The use of rigid basements with mat foundations could be used for buildings up to two stories high, and an impressed pressure of 2,000 psf at the bottom of the foundations.

High liquid limits and low compression strengths of the complex chemical subgrade under slabs on grade limits the applied pressure on to these slabs. The applied pressure should not exceed four times the transverse shear value of the subgrade. The applied pressure is estimated to be not more than 1,000 psf.

Concrete pavements should be avoided whenever possible; jointing pattern should be studied so as to attain closely spaced control joints. The paving should have reinforcing in both directions so as to distribute the load and to provide load transfer from one slab section to the other.

Sanitary lines would slope to southern parts of the island as part of the Grosse Ile master sewage system. Storm water would drain to the river if the quality of the runoff water is controlled. If any towers are required, they may be required to be supported on deep foundations.

Vegetation for landscape cannot sustain on this chemical surface. The site would be required to be covered with adequate thickness of topsoil in order to sustain grass, shrubs, or trees. This soil should be distributed over the site relatively evenly so as not to cause mass stability problems.

Summary Recommendations

1. Use spread footings for all structures with light loads. Footings should be sized for 2,000 psf total load. Buildings should not be more than two stories.
2. Provide basement to all buildings. The basement slab should be a rigid mat, and should be designed to sustain 2,000 psf uplift pressure.
3. Buildirgs with heavy column loads should be supported on piles or caissons, which shall extend down to hardpan.
4. Use bituminous road paving.
5. Slabs on grade shall have closely spaced control joints and shall be reinforced in both directions.
6. Towers and similar heavy structures should rest on deep

APPENDIX B

Soils Exploration Report
Michigan Drilling

MICHIGAN DRILLING
DIVISION OF MICHIGAN TESTING ENGINEERS, INC.
CONSULTING ENGINEERS IN SOILS & FOUNDATIONS
14555 WYOMING AVENUE • DETROIT, MICHIGAN 48238 • PHONE (313) 933-9366

JULY 24, 1972

WYANDOTTE CHEMICAL COMPANY
1609 BIDDLE STREET
WYANDOTTE, MICHIGAN 48192

JOB NO. 72-616

ATTENTION: MR. PIPER

SUBJECT: SOILS EXPLORATION
PROPOSED BUILDING
WYANDOTTE CHEMICAL COMPANY
GROSSE ILE, MICHIGAN

GENTLEMEN:

IN ACCORDANCE WITH YOUR INSTRUCTIONS, WE HAVE MADE A SOILS INVESTIGATION ON THE PROJECT STATED ABOVE. THIS CONSISTED OF TWO (2) SOIL TEST BORINGS. BORING NUMBER 1 (ONE) WAS DRILLED TO A DEPTH OF FORTY-FIVE FEET (45') AND BORING NUMBER 2 (TWO) WAS DRILLED TO A DEPTH OF TWENTY-ONE FEET (21') BELOW THE EXISTING GROUND SURFACE. THESE BORINGS WERE MADE IN THE LOCATIONS SHOWN TO THE CREW BY MR. PIPER.

TWO (2) SHELBY TUBE SAMPLES WERE OBTAINED IN EACH LOCATION AT DEPTHS STATED ON THE RESPECTIVE BORING LOG. LABORATORY TESTS PERFORMED ON THESE SAMPLES ARE DETAILED IN TABLE NUMBER 1.

TABLE NUMBER 1

S. No.	TYPE OF TEST	LOCATION
1	TRIAXIAL TESTS	BORING #1, SHELBY TUBE #1
2	" "	BORING #1, SHELBY TUBE #2
3	" "	BORING #2, SHELBY TUBE #2
4	ATTERBERG LIMITS(L.L.,P.L. AND S.L.)	BORING #1, SHELBY TUBE #1
5	" "	BORING #1, SHELBY TUBE #2
6.	" "	BORING #2, SHELBY TUBE #2

THE UNCONFINED COMPRESSIVE STRENGTH DATA MAY BE OBTAINED FROM THE FIRST MOHR CIRCLE ON EACH OF THE STRENGTH ENVELOPES. THIS WAS DONE TO REDUCE THE COST OF THE PROJECT.

SAMPLE OBTAINED FROM BORING NUMBER 2, SHELBY TUBE #1 WAS RELATIVELY DISTURBED. HENCE, IT WAS NOT TESTED.

DETAILED TEST RESULTS ARE TO BE FOUND ON THE DATA SHEETS ENCLOSED.

IF YOU HAVE ANY QUESTIONS, PLEASE DO NOT HESITATE TO CALL UPON US.

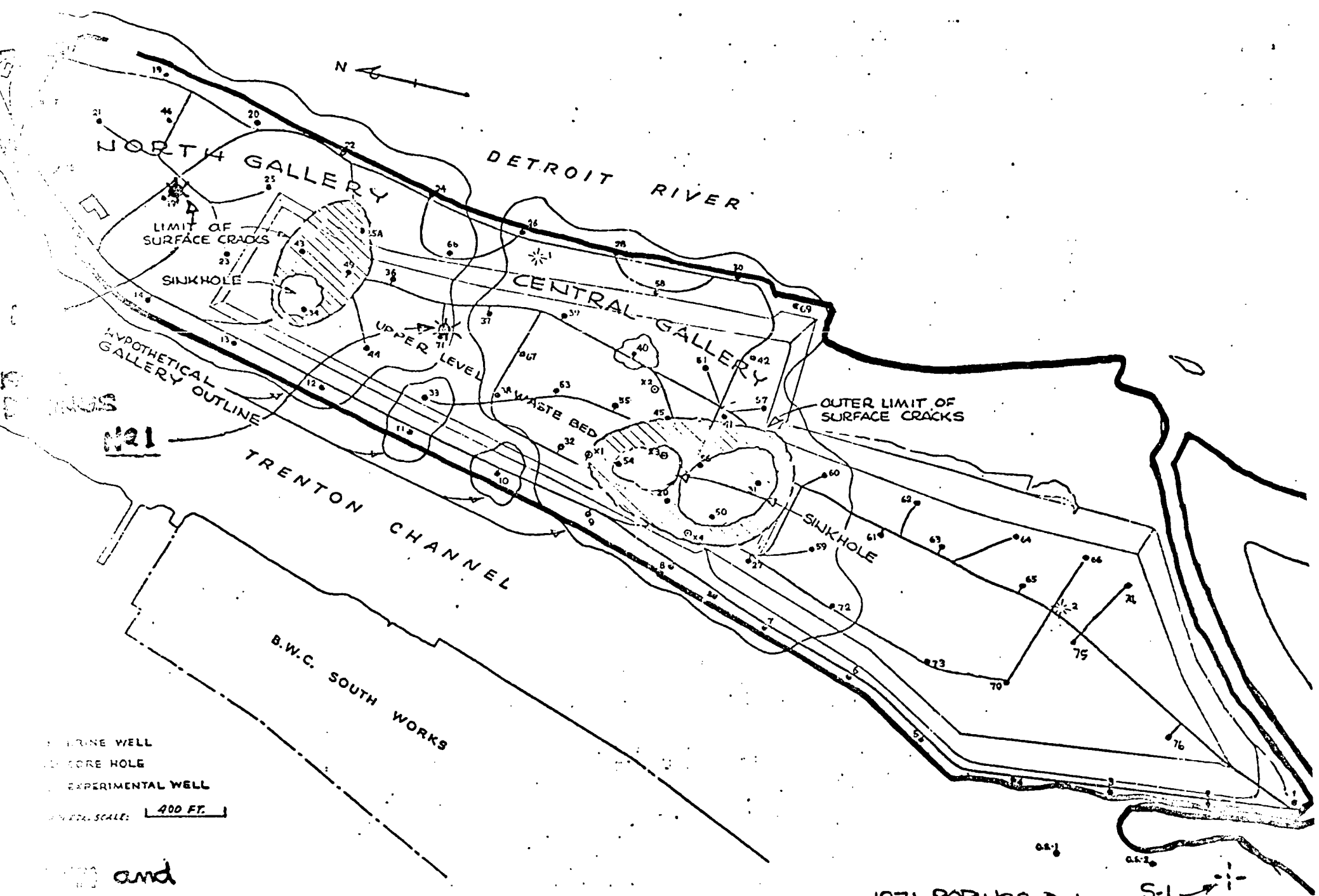
VERY TRULY YOURS,

MICHIGAN DRILLING DIVISION
MICHIGAN TESTING ENGINEERS, INC.

S. B. SEHGAL, PH.D. E. S.
DIRECTOR OF SOILS ENGINEERING

SBS:ES

CC: SMITH, HINCHMAN & GRYLLS



and

SOIL BORINGS –

GROSSE ILE BRINE FIELD

1971 BORINGS D-1 S-1

MICHIGAN DRILLING CO. JOB 71-97K

MICHIGAN DRILLING

DIVISION OF MICHIGAN TESTING ENGINEERS INC
CONSULTING ENGINEERS IN SOILS & FOUNDATIONS
14555 WYOMING AVENUE • DETROIT, MICHIGAN 48238

JOB NO. 72-616 LOG OF SOIL BORING NO. 1

PROJECT PROPOSED BUILDING

LOCATION WYANDOTTE CHEMICAL CO.
GROSSE ILE, MICHIGAN

DATE 6-21-72 SURFACE ELEV.

Sample & Type	Depth	Legend	SOIL DESCRIPTION	Penetration Blows For 6"			Moisture %	Natural Wt. P.C.F.	Unc. Comp. Str. Strength PSF.
			0'0"						
A	2	fill	MEDIUM COMPACT MOIST CINDERS, STONES, FILL	1	½	1			
UL	4								
B			LOOSELY COMPACT MOIST CHEMICAL FILL	½	½	1			
UL	6								
C			7'0"						
UL	8	fill	SLIGHTLY COMPACT MOIST CHEMICAL FILL	½	1	1			
D	10			1	1	1½			
UL									
	12								
			13'0"						
	14								
E		fill	MEDIUM COMPACT MOIST CHEMICAL FILL	2	2	3			
UL	16								
			17'3"						
	18								
F	20			1	1	2			
UL			SLIGHTLY COMPACT MOIST CHEMICAL FILL						
	22	fill							
	24								
G									
UL	26			2	2	2			
	28								
H	30			1	2	1			
UL									
	32		32'0"						
	34								
I			LOOSELY COMPACT NATURAL CHEMICAL FILL	½	½	½			
UL	36	fill							
	38								
			39'0"						
J	40		FIRM MOIST ORGANIC RIVER BOTTOM, PEAT	2	3	3			
UL									
	42		42'0"						
	44		STIFF MOIST SANDY ORGANIC CLAY						
K			45'0"	3	4	4			
UL	46								
	48								
	50								
	52								
	54								
	56								
	58								
	60								

NOTE: S.T.#1 PUSH FROM 5' TO 6'6"
R=1'6"

NOTE: S.T.#2 PUSH FROM 23' TO 24'6"
R=1'4"

MICHIGAN DRILLING

DIVISION OF MICHIGAN TESTING ENGINEERS INC
CONSULTING ENGINEERS IN SOILS & FOUNDATIONS
14555 WYOMING AVENUE • DETROIT, MICHIGAN 48238

JOB NO. 72-616 LOG OF SOIL BORING NO. 2

PROJECT PROPOSED BUILDING

LOCATION WYANDOTTE CHEMICAL CO.
GROSSE ILE, MICHIGAN

DATE 6-21-72 SURFACE ELEV.

Sample & Type	Depth	Legend	SOIL DESCRIPTION	Penetration Blows For 6"	Moisture %	Natural Wt. P.C.F.	Unc. Comp. Strength PSF.
A UL	1–3		MEDIUM COMPACT MOIST CINDERS, STONES, CHEMICAL FILL	8 3 2			
	3'0"						
B UL	4–6		LOOSELY COMPACT CHEMICAL FILL	1 ½ ½			
	6'6"						
C UL	7–9			4 3 1			
D UL	10–14		SLIGHTLY COMPACT CHEMICAL FILL	1 2 1			
	14'6"						
E UL	15–18		FIRM MOIST ORGANIC RIVER BOTTOM	1 2 3			
	19'0"						
F UL	20–21		COMPACT WET MEDIUM MIXED SAND	6 7 8			
	21'0"						

NOTE: S.T.#1 PUSH FROM 5' TO 6'6"
R=1'4"

NOTE: S.T.#2 PUSH FROM 18' TO 19'6"
R= 1'4"

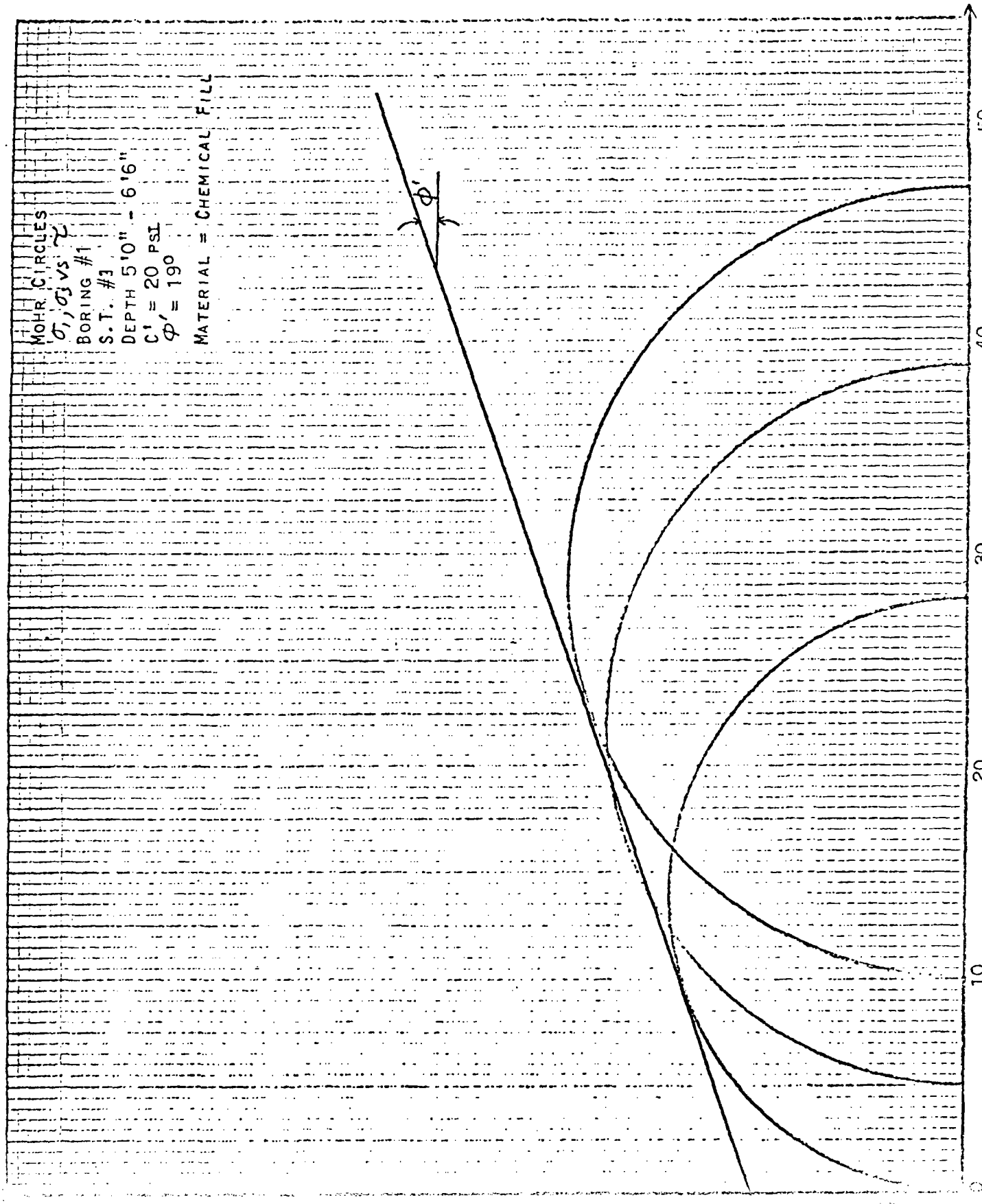
S.T.–SHELBY TUBE

DEPTHS OF AND

G.W. AFTER COMPLETION FT.

JCB NO. 72-616
PROJECT: PROPOSED BUILDING
ARCHT./ENGR. SMITH, HINCHMAN & GRYLLS
DATE 7-5-72

MICHIGAN DRILLING CO.
14555 WYOMING AVENUE
DETROIT 38, MICHIGAN
WEBSTER 3-8717 – 3-1739



MICHIGAN DRILLING DIVISION
MICHIGAN TESTING ENGINEERS

FILE NO. 72-616

PROJECT NAME PROPOSED BUILDING
JOB NO. 72-616

SAMPLE DATA

BORING NUMBER	B #1	B #1	B #1	
SAMPLE NUMBER	S.T.#1-1	S.T. #1-2	S.T.#1-3	
DEPTH, FT.	5'-6'6"	5'-6'6"	5'-6'6"	
INITIAL WATER CONTENT, %	80	84.5	87.5	
INITIAL VOID RATIO				
INITIAL SATURATION, %				
INITIAL DIAMETER, IN.	1.375	1.375	1.375	
INITIAL HEIGHT, IN.	2.75	2.75	2.75	
DRY DENSITY, PSF.	40.8	40.8	40.8	
FINAL WATER CONTENT %	80.0	84.5	87.5	
FINAL VOID RATIO				
FINAL DIAMETER TOP	1.370	1.365	1.360	
FINAL DIAMETER MIDDLE	1.380	1.385	1.390	
IN. INCHES BOTTOM	1.380	1.380	1.365	
FINAL HEIGHT, IN.	2.40	2.35	2.25	

EXPERIMENTAL DATA

TYPE OF EXPERIMENT	UNCONSOLIDATED UNDRAINED			
METHOD OF SATURATION				
BACK PRESSURE,. PSF.				
MINOR PRINCIPAL STRESS, PSF.	0	720	1440	
MAXIMUM DEVIATOR STRESS, PSF.	4035	5600	6750	
RATE OF STRAIN IN/MIN.	.05	.05	.05	
TIME TO FAILURE, MIN.	2	3	5	

EXPERIMENTAL RESULTS

TYPE OF SPECIMEN: CHEMICAL FILL

SHEAR STRENGTH PARAMETERS

$\tan\phi' = .344$

$\phi' = 19^{\circ}$

$c' = 2880$ PSF.

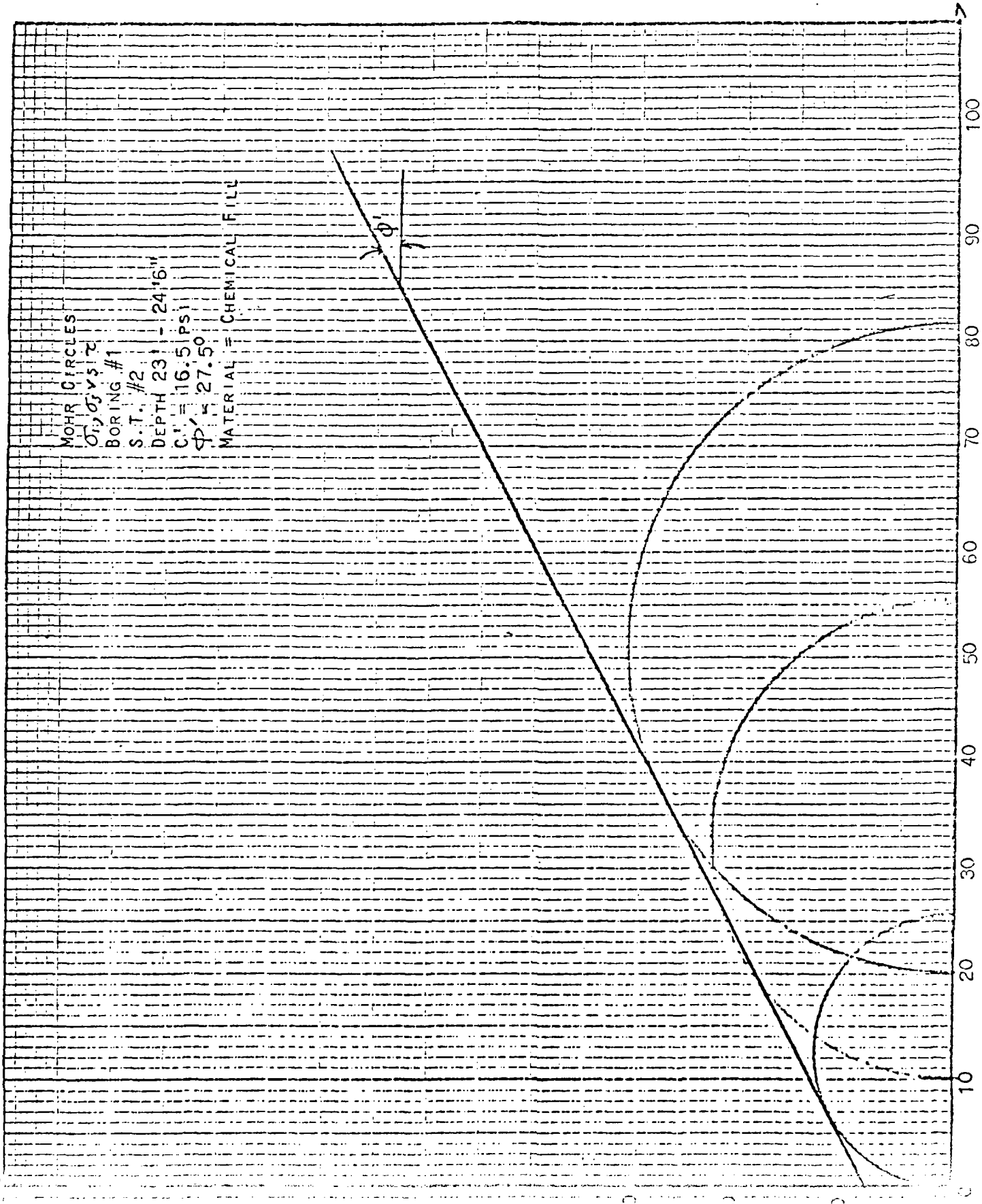
JOB NO. 72-616

PROJECT: PROPOSED BUILDING

ARCHT./ENGR. SMITH, HINCHMAN, GRYLLS

DATE 7-5-72

MICHIGAN DRILLING CO.
14555 WYOMING AVENUE
DETROIT 38, MICHIGAN
WEBSTER 3-8717 – 3-1739



σ1 σ3 in psi

MICHIGAN DRILLING DIVISION
MICHIGAN TESTING ENGINEERS

FILE NO.

PROJECT NAME PROPOSED BUILDING
JOB NO. 72-616

SAMPLE DATA

BORING NUMBER	B #1	B #1	B #1	
SAMPLE NUMBER	ST 2-1	ST 2-2	ST 2-3	
DEPTH, FT.	23' - 24'6"	23' - 24'6"	23'-24'6"	
INITIAL WATER CONTENT, %	115	137	106	
INITIAL VOID RATIO				
INITIAL SATURATION, %				
INITIAL DIAMETER, IN.	1.375	1.375	1.375	
INITIAL HEIGHT, IN.	2.75	2.75	2.75	
DRY DENSITY, PSF.	35.7	35.7	35.7	
FINAL WATER CONTENT %	115	137	106	
FINAL VOID RATIO				
FINAL DIAMETER IN. INCHES — TOP	1.370	1.370	1.365	
FINAL DIAMETER IN. INCHES — MIDDLE	1.380	1.380	1.390	
FINAL DIAMETER IN. INCHES — BOTTOM	1.370	1.365	1.360	
FINAL HEIGHT, IN.	2.65	2.50	2.40	

EXPERIMENTAL DATA

TYPE OF EXPERIMENT	UNCONSOLIDATED UNDRAINED			
METHOD OF SATURATION				
BACK PRESSURE, PSF.				
MINOR PRINCIPAL STRESS, PSF.	0	1440	2880	
MAXIMUM DEVIATOR STRESS, PSF.	3640	82000	11700	
RATE OF STRAIN IN/MIN.	.05	.05	.05	
TIME TO FAILURE, MIN.	2	5	7	

EXPERIMENTAL RESULTS

TYPE OF SPECIMEN: CHEMICAL FILL

SHEAR STRENGTH PARAMETERS

$\text{TAN}\phi' = .520$
$\phi' = 27.5^\circ$
$c' = 2370$ PSF.

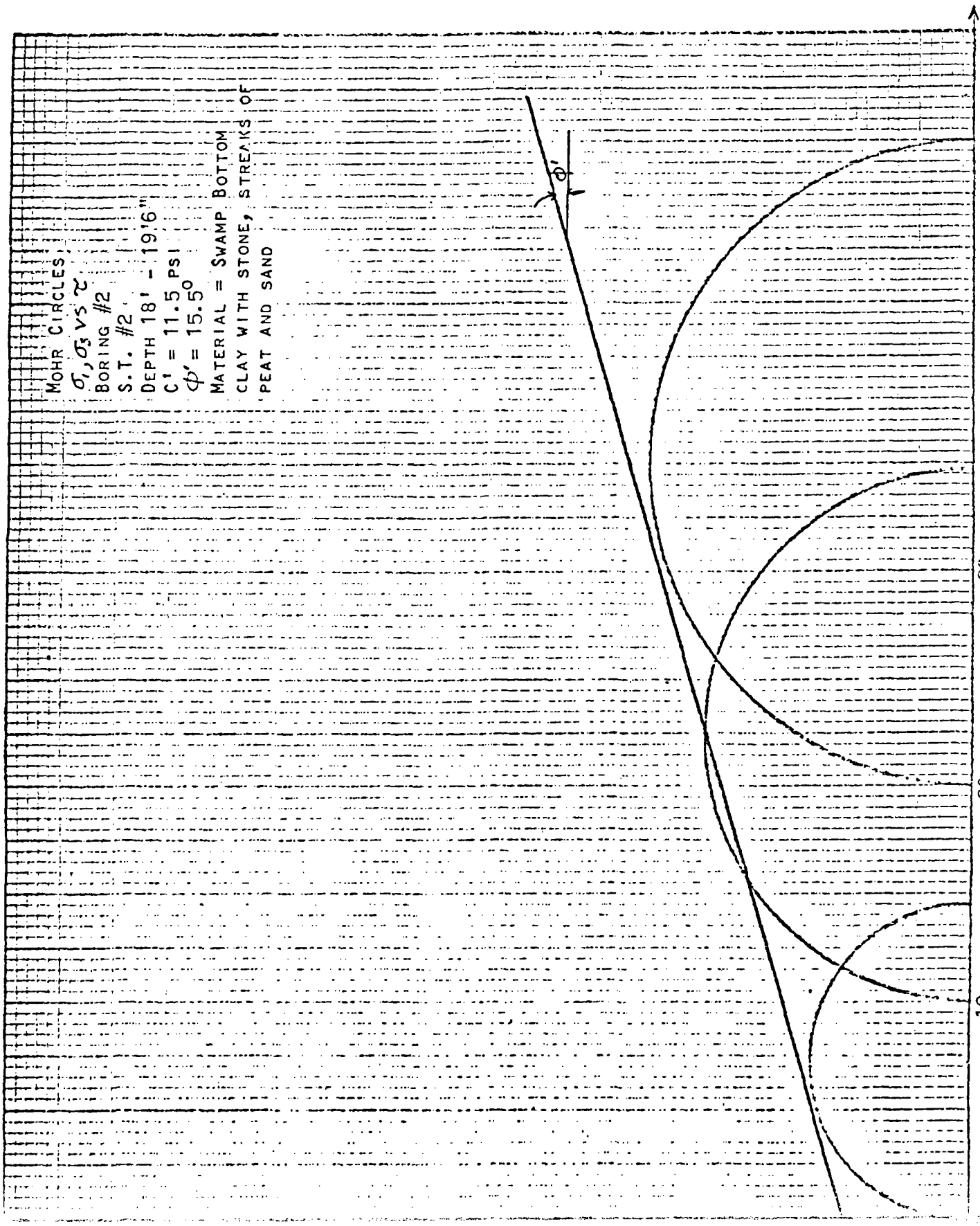
JOB NO. 72-616

PROJECT: PROPOSED BUILDING

ARCHT./ENGR. SMITH, HINCHMAN & GRYLLS

DATE 7-5-72

MICHIGAN DRILLING CO.
14555 WYOMING AVENUE
DETROIT 38, MICHIGAN
WEBSTER 3-8717 – 3-1739



250 N/2

MICHIGAN DRILLING DIVISION
MICHIGAN TESTING ENGINEERS

FILE NO.

PROJECT NAME Proposed Building
JOB NO. 72-616

SAMPLE DATA

Boring Number	B #2	B #2	B #2	
Sample Number	S.T. 2-1	S.T. 2-2	S.T. 2-3	
Depth, Ft.	18'-19'6"	18' - 19'6"	18' - 19'6"	
Initial Water Content, %	19.1	18.4	20.1	
Initial Void Ratio				
Initial Saturation, %				
Initial Diameter, in.	1.375	1.375	1.375	
Initial Height, in.	2.75	2.75	2.75	
Dry Density, psf.	102.0	102.0	102.0	
Final Water Content %	19.1	18.4	20.1	
Final Void Ratio				
Final Diameter Top	1.370	1.365	1.365	
Final Diameter Middle	1.380	1.385	1.380	
Final Diameter Bottom	1.365	1.365	1.380	
Final Height, in.	2.45	2.40	2.25	

EXPERIMENTAL DATA

Type of Experiment	Unconsolidated Undrained			
Method of Saturation				
Back Pressure, psf.				
Minor Principal Stress, psf.	0	1440	2880	
Maximum Deviator Stress, psf.	2830	5020	7200	
Rate of strain in/min.	.05	.05	.05	
Time to Failure, min.	6	7	10	

EXPERIMENTAL RESULTS

Type of Specimen: Swamp Bottom clay with some streaks of peat and sand

Shear Strength Parameters:

$\tan\phi' = \frac{-277}{1}$

$\phi' = 15.5^{\circ}$

$c' = 1660$ psf.

MICHIGAN DRILLING DIVISION
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DETROIT, MICHIGAN 48238

JOB. NO. 72-616
DATE 7/24/72

SHRINKAGE LIMIT TEST RESULTS

SAMPLE NUMBER		1						
DEPTH		18'-19'6"						
DISH NUMBER		21						
WT. OF WET SOIL AND DISH		41.94						
WT. OF DRY SOIL AND DISH		36.41						
WT. OF WATER		5.53						
WT. OF DISH		10.71						
WT. OF DRY SOIL		27.70						
MOISTURE CONTENT		21.5						
VOLUME OF DISH		15.45						
VOLUME OF DRY SOIL		13.86						

$$\text{SHRINKAGE LIMIT} = \text{MOISTURE CONTENT} - \frac{\text{VOLUME OF DISH} - \text{VOLUME OF DRY SOIL} \times 100}{\text{WEIGHT OF DRY SOIL}}$$

$$= 21.5 - \frac{(15.45 - 13.86)}{25.70} \times 100 = 15.31$$

$$\text{SHRINKAGE RATIO} = \frac{\text{WEIGHT OF DRY SOIL}}{\text{VOLUME OF DRY SOIL}} = \frac{25.70}{13.86} = 1.85$$

REMARKS UNITS: C.G.S. SYSTEM

MATERIAL: SWAMP BOTTOM CLAY

SHEET # 2/6

PROJECT

LOCATION

TESTED BY: H.P.&F.S. APPROVED BY: H.P.

DCL-4 Job No. 72-616

Name: PROPOSED BUILDING Sample Number ST #2 - TB #2

Date: 7/24/72 Sheet Number 1/6

LIQUID AND PLASTIC LIMIT DETERMINATIONS
DATA AND COMPUTATION SHEET

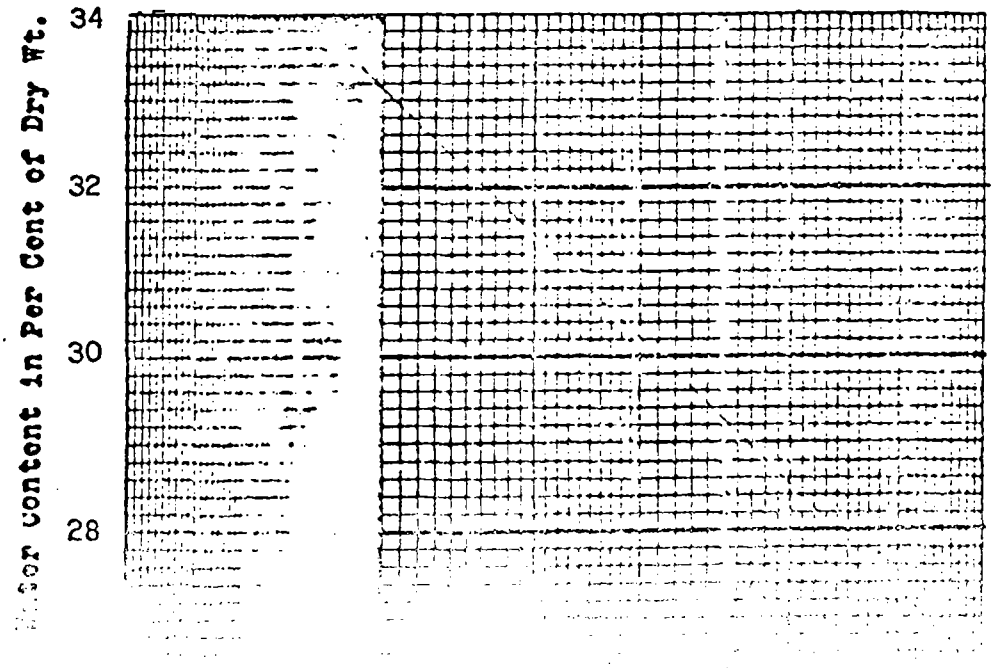
DEPTH: 18' - 19'6"

LL = Liquid Limit Test **PL = Plastic Limit Test**

Type of Test		LL	LL	LL	LL	LL
Container Number		7	9	13	22	
Number of Blows	X	38	21	11	28	
Wt. Sample + Tare Wet		46.37	52.44	50.10	57.13	
Wt. Sample + Tare Dry		42.90	47.28	45.04	52.36	
Wt. of Water		3.47	5.16	5.06	4.77	
Tare		30.30	30.06	29.88	35.65	
Wt. of Dry Soil		12.60	17.22	15.16	16.71	
Water Content		27.6	30.0	33.4	28.5	

Type of Test			PL	PL	PL	
Container Number			5	18		
Number of Blows			X	X	X	
Wt. Sample + Tare Wet			49.54	38.81		
Wt. Sample + Tare Dry			47.58	37.63		
Wt. of Water			1.96	1.18		
Tare			35.06	29.80		
Wt. of Dry Soil			12.56	7.83		
Water Content			15.6	15.1		

FLOW CURVE



RESULTS

Liquid Limit = 29.20 %

Plastic Limit = 15.35 %

Plasticity Index = 13.85

Flow Index = _____ %

Toughness Index = _____ %

Remarks: MATERIAL: SWAMP BOTTOM CLAY

MICHIGAN DRILLING DIVISION
MICHIGAN TESTING ENGINEERS, INC.
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DETROIT, MICHIGAN 48238

JOB. NO. 72-616
DATE 7/24/72

SHRINKAGE LIMIT TEST RESULTS

SAMPLE NUMBER		1						
DEPTH		23' - 24'6"						
DISH NUMBER		10						
WT. OF WET SOIL AND DISH		31.48						
WT. OF DRY SOIL AND DISH		20.85						
WT. OF WATER		10.63						
WT. OF DISH		10.72						
WT. OF DRY SOIL		10.13						
MOISTURE CONTENT		105.0						
VOLUME OF DISH		15.05						
VOLUME OF DRY SOIL		13.15						

$$\text{SHRINKAGE LIMIT} = \text{MOISTURE CONTENT} - \frac{\text{VOLUME OF DISH} - \text{VOLUME OF DRY SOIL}}{\text{WEIGHT OF DRY SOIL}} \times 100$$

$$= 105 - \frac{15.05 - 13.15}{10.13} \times 100 = 105 - \frac{190}{10.13} = 86.25$$

$$\text{SHRINKAGE RATIO} = \frac{\text{WEIGHT OF DRY SOIL}}{\text{VOLUME OF DRY SOIL}} = \frac{10.13}{13.15} = 0.77$$

REMARKS UNITS: C.G.S SYSTEM

MATERIAL: CHEMICAL FILL (NOT CLEAN)

SHEET # 4/6

PROJECT

LOCATION

TESTED BY: H.P.&F.S. APPROVED BY: H.P.

DCL-4

Job No. 72-616

Name: PROPOSED BUILDING

Sample Number TB #1 - ST #2

Date: 7/24/72

Sheet Number 3/6

Depth: 23' - 24'6"

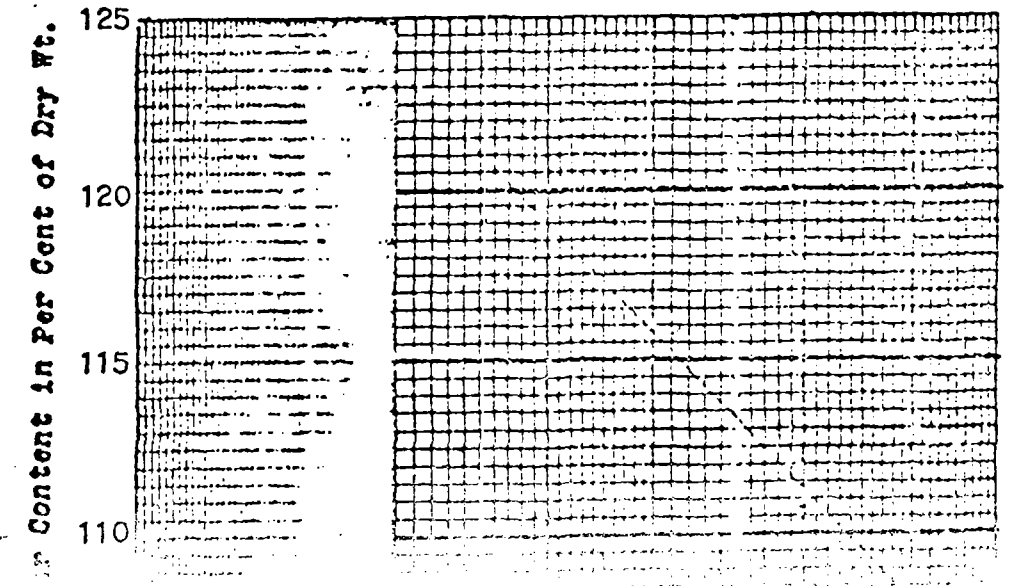
LIQUID AND PLASTIC LIMIT DETERMINATIONS
DATA AND COMPUTATION SHEET

LL = Liquid Limit Test PL = Plastic Limit Test

Type of Test		LL	LL	LL	LL	LL
Container Number		A	D	E	G	
Number of Blows		13	21	30	36	
Wt. Sample + Tare Wet		43.32	41.90	40.77	44.98	
Wt. Sample + Tare Dry		33.54	33.24	32.00	34.13	
Wt. of Water		9.78	8.66	8.77	10.85	
Tare		25.40	25.76	24.12	24.17	
Wt. of Dry Soil		8.14	7.48	7.88	9.96	
Water Content		120	116	111	109.	

Type of Test			PL	PL	PL	
Container Number			15	20	23	
Number of Blows						
Wt. Sample + Tare Wet			33.48	35.12	36.62	
Wt. Sample + Tare Dry			32.21	34.49	35.48	
Wt. of Water			1.27	0.63	1.14	
Tare			30.94	33.84	34.30	
Wt. of Dry Soil			1.27	0.65	1.18	
Water Content			100.0	97.0	97.0	

FLOW CURVE



RESULTS

Liquid Limit = 113.25 %

Plastic Limit = 98.0 %

Plasticity Index = 15.25

Flow Index = _____ %

Toughness Index = _____ %

Remarks: MATERIAL: CHEMICAL FILL

MICHIGAN DRILL DIVISION
MICHIGAN TESTING ENGINEERS, INC.
14555 WYOMING AVENUE
DETROIT, MICHIGAN 48238

JOB. No. 72-616
DATE 7/24/72

SHRINKAGE LIMIT TEST RESULTS

SAMPLE NUMBER		1						
DEPTH		5'-6'6"						
DISH NUMBER		23						
WT. OF WET SOIL AND DISH		32.89						
WT. OF DRY SOIL AND DISH		22.4						
WT. OF WATER		10.48						
WT. OF DISH		10.72						
WT. OF DRY SOIL		11.69						
MOISTURE CONTENT		89.8						
VOLUME OF DISH		14.90						
VOLUME OF DRY SOIL		13.20						

$$\text{SHRINKAGE LIMIT} = \text{MOISTURE CONTENT} - \frac{\text{VOLUME OF DISH} - \text{VOLUME OF DRY SOIL}}{\text{WEIGHT OF DRY SOIL}} \times 100$$

$$= 89.8 - \frac{14.90 - 13.20}{11.69} \times 100 = 75.2\%$$

$$\text{SHRINKAGE RATIO} = \frac{\text{WEIGHT OF DRY SOIL}}{\text{VOLUME OF DRY SOIL}} = \frac{11.69}{13.20} = .855$$

REMARKS UNITS: C.G.S. SYSTEM

MATERIAL: CLEAN CHEMICAL FILL

SHEET: 6/6

PROJECT

LOCATION

TESTED BY: H.P&F.S. APPROVED BY: H.P.

DCL-4

Job No. 72-616

Name: PROPOSED BUILDING

Sample Number T.B. #1 - ST #1

Date: 7/24/72

Sheet Number 5/6

DEPTH: 5' - 6'6"

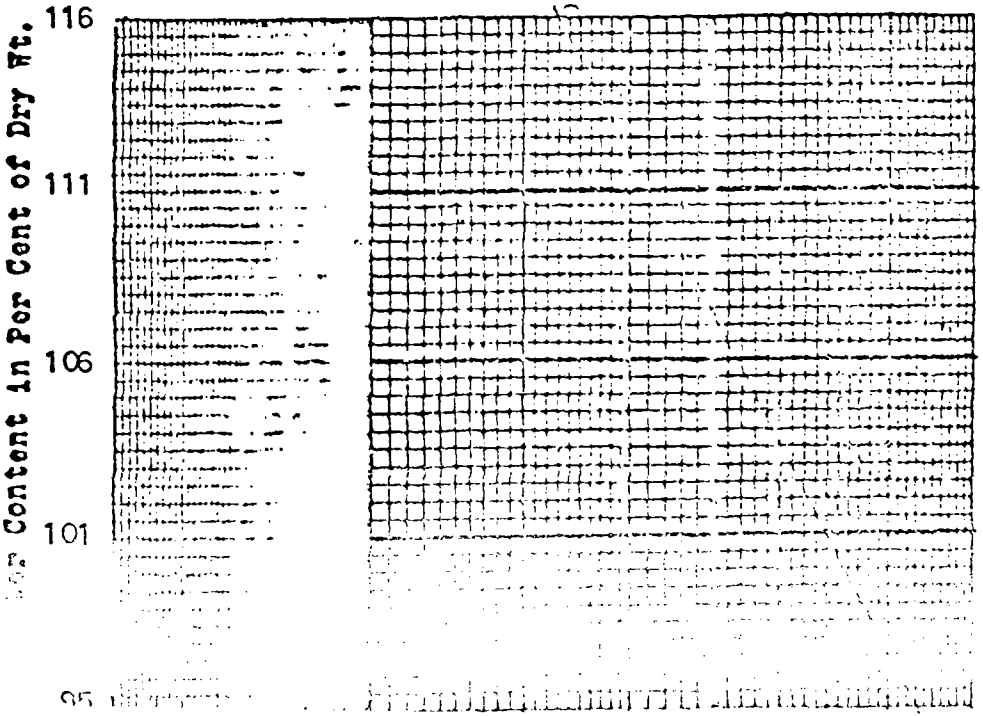
LIQUID AND PLASTIC LIMIT DETERMINATIONS
DATA AND COMPUTATION SHEET

LL = Liquid Limit Test **PL = Plastic Limit Test**

Type of Test		LL	LL	LL	LL	LL
Container Number		S-2	14	F	0	
Number of Blows		17	23	29	42	
Wt. Sample + Tare Wet		47.12	42.54	36.29	46.74	
Wt. Sample + Tare Dry		40.81	35.61	30.91	40.62	
Wt. of Water		6.31	6.93	5.38	6.12	
Tare		35.40	29.33	25.68	34.23	
Wt. of Dry Soil		5.41	6.28	5.23	6.39	
Water Content		116.5	110	103.0	96.0	

Type of Test			PL	PL	PL	
Container Number			6-A	41		
Number of Blows						
Wt. Sample + Tare Wet			32.93	30.04		
Wt. Sample + Tare Dry			29.56	27.91		
Wt. of Water			3.37	2.13		
Tare			25.28	25.32		
Wt. of Dry Soil			4.28	2.59		
Water Content			79	83		

FLOW CURVE



RESULTS

Liquid Limit = 107.25 %

Plastic Limit = 81.0 %

Plasticity Index = 26.25

Flow Index = _____ %

Toughness Index = _____ %

Remarks: _____

APPENDIX C

Corehole No. 2 - Composite Log
(partial log upper 100')